8th CANADIAN WASTE MANAGEMENT CONFERENCE

8ième CONFÉRENCE CANADIENNE SUR LA GESTION DES DÉCHETS

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Halifax

Le 3, 4 et 5 septembre 1986
Hôtel Sheraton
Halifax

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The steering Committee of the 8th National Conference on Waste Management in Canada wishes to record it's appreciation of the efforts of the panelists for preparing the outlines of their papers and their subsequent delivery and to the panel moderators for guiding panelists and audience during the conference sessions.

Le comité d'organisation de la 8ième Conférence nationale sur la gestion des déchets au Canada aimerait noter son appréciation auprès des conférenciers pour la préparation de leur présentation ainsi qu'aux modérateurs pour leur aide soutenue lors du déroulement de la conférence.

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OVERCOMING THE BARRIERS TO PUBLIC ACCEPTANCE OF WASTE MANAGEMENT FACILITIES

Desmond M. Connor,
Connor Development Services Ltd.
Ann C. Svendsen,
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INTRODUCTION

Public opposition to waste management facilities has become the most critical problem facing both the industry and the communities it serves. The situation in the metropolitan areas in the north-eastern U.S. are facing an immediate crisis. A recent national (1) study by the Institute of Environmental Studies at the University of Toronto indicates that waste management engineers across Canada believe that public opposition is their most important problem, that it will remain so and that they are ill-prepared to deal with it.

Why does waste management generate so much public concern? Some of the factors are: it is an essential service; waste composition is seen as increasingly hazardous; the technology for waste management is changing rapidly; public understanding of waste management issues and options is often ten years out of date; waste management failures can threaten the health and life of those who live near waste management facilities; following recent chemical and nuclear disasters, more and more people distrust technology, experts and government officials. As a result, NIMBY (Not in My Backyard or Now I Must Become Involved) and LULU (Locally Unwanted Land Use) have become household words and the subject of major publications and conferences. (2)

This paper is based on the authors' experience in both central and western Canada over a 15 year period with some 20 waste management projects ranging across landfills, resource recovery plants, waste management plans, and hazardous waste disposal. Some of these have been in small communities; the recent Lower Mainland Refuse Project covered 1-1/2 million people, while the current Ontario Waste Management Corporation's assignment covers the Province of Ontario.

Our paper first identifies a number of barriers to public acceptance, then indicates some approaches to dealing with each barrier and concludes with a case study of our work with the Lower Mainland Refuse Project in B.C.

SOME BARRIERS

1. The environment - social, political and economic - of our society has changed during the past decade. We used to have relatively small communities which changed slowly and were inhabited by much the same kinds of people. They respected authority, legal, expert and political, and were generally satisfied with life.

Today we typically have larger communities where social change is rapid, the population is heterogeneous, and people distrust authorities and experts. Many have high levels of generalized anxiety and hostility due to their experiences and fears of inflation, unemployment and other concerns.

2. Shifts in values are growing from traditional assumptions to what were formerly characterized as the views of "far-out Californians". For example, the majority of people still believe that: man is the master of nature; bigger is better; ownership rights are important; individual freedom and personal responsibility are critical.

However, we must recognize that growing minorities of people, many of them well-educated, articulate and organizationally astute, believe that: people should live more in harmony with Mother Nature; small is beautiful; owners have social responsibilities; a sense of community limits rugged individualism; people are entitled to certain rights, including a healthy environment.

Notice how this process develops from an initial docile minority, e.g. non-smokers, to a growing but unconscious number of individuals, to a realization that there is a developing community of interest which often leads to a voluntary organization being formed, to a demonstration of majority status and demands for rights and legislation to secure them. If you are a waste management professional and haven't read Marilyn Ferguson's Acquarian Conspiracy,(3) it's time you did!

3. Perceived inequity occurs when one group or community seems to be asked to shoulder more than its fair share of needed but unpopular facilities. In many cases, people have selected a quiet area in which to live and suddenly they find their new neighbour is going to be a four-lane highway, a factory or a waste management facility. In addition, they may believe that they will not receive adequate compensation and social recognition.

This situation is almost guaranteed to create a vociferous NIMBY group. If residents feel little sense of identity with the planning and decision-making body, e.g. a newly formed regional government, this reaction is even more likely. Many will then rally to their traditional local municipal organizations to fight the regional government and its waste management plan.

4. Perceived risk develops when images arise in people's minds and shape their behaviour, regardless of the technical facts of the situation. A classic case occurred when a waste management agency announced a sanitary landfill to a population unaware and ignorant about the community's waste management needs and plans. A newspaper story stated "We don't want any Love Canal here" and triggered a powerful negative image - which of course was quite inappropriate for the situation. Once entrenched, these images are very difficult to change.

5. Public misconceptions, positive and negative, about the value of alternative technologies, are often promoted by special interest groups, proponents of particular technologies and feature stories in the media. e.g. gold from garbage; incineration as a panacea; the marvels of composting. Just as in very heresy there is some truth, so each of these technologies may have a limited place in a specific waste management plan, but not the grand role promoted by their supporters.

Public misconceptions and perceived risk problems both occur most often when the public has been kept in a informational vacuum. A useful parallel here is that most of us believe that short-changing a child's education is a poor form of economy. Similarly, saving money on adult education about waste management can be expensive in the long-run when a ignorant and angry public block needed plans and facilities.

6. Management by crisis occurs when proponents create or accept severe time constraints which make it impossible to deal effectively with the concerns of the public and their desire to provide meaningful input to the waste management plan. As a result arbitrary decisions are made by specialists and politicians behind closed doors about sites and methods. When these are announced controversy erupts and the crisis continues. Strangely, when there is no time to do the job right, there always seems to be time later to do it over again. Associated with management by crisis is "schizophrenic management". While the technical side of a project is designed and managed in a rational, scientific and professional manner, yet the problematic public side of the project is

dealt with in a totally ad hoc, reactive and unplanned fashion. How is it that a project manager can act in two such different ways about the same project?

7. Polarization takes place when continuing opposition leads to hardened positions after a long public debate over an issue. Protagonist and antagonist typically become locked into public statements which neither can retreat from without a major loss of face.

8. Overlegalization occurs when a complex legal process prevents the meeting of minds and fosters an adversarial climate and an endless series of moves and countermoves. In many cases, legislation constrains a more open process amongst the parties and with the public, e.g. the formal hearings process with evidence under oath and cross examination by counsel.

9. Technical information overload happens when the proponent fails to translate technical documents into simpler forms so the information is accessible to the general public. In other cases, it is important to synthesize scientific information and to condense complex policy issues, options and tradeoffs into a manageable format. This situation is often associated with a failure to break the process into meaningful components and indicate to the public the opportunities for relevant input.

10. Organizational culture gaps. In many cases the proponent organization develops a set of guiding values, goals and ways of working which are increasingly estranged from the daily lives and concerns of the people it is supposed to serve. Lacking a systematic monitoring of its external social, political and economic environment, a "two solitudes" situation develops which is only recognized when a unexpected public uproar follows what the organization felt was a routine policy development.

While many more specific barriers can be identified, we believe that these 10 are among the major obstacles to the acceptance of waste management facilities by the public.

OVERCOMING THE BARRIERS

For each of these barriers, we will now outline a use-tested approach which we have found effective in previous projects.

1. Environmental monitoring provides a regular, systematic and professional social data base which is the essential foundation for planning and managing an effective program of public information and consultation.

A community profile (4) is an effective means of obtaining a sound grasp of the social realities of the people of an area where a waste management facility is being considered. For a larger area, a telephone survey of a sample of the residents will provide information about their knowledge of and attitudes to waste management. Issue management (5) provides a medium range perspective on probable waste management issues likely to occur in a community or region and how they might best be dealt with in a preventive way.

2. Value tracking is one way to follow the value shifts which are especially relevant for waste management, e.g. attitudes to recycling and incineration. Following the use of one or more of the general environmental techniques noted above, the various public for waste management can be identified and their views on critical topics can be invited through ongoing activities, e.g. at Open Houses in connection with a specific project, during Recycling Week, through municipal or interest group newsletters, during presentation to key interest groups, etc.

While none of these qualitative measures is sufficient in itself, used in combination over time, they can provide insights in how the minds of the various publics are evolving. Sharing the results of these observations with the other publics can help to inform the consideration of waste management issues by developing a more aware and insightful general public.

3. Social impact assessment and management is one means of dealing with perceived inequity, particularly when a participative approach is employed. (6) The first step is to identify each public's perception of the equity differential, e.g. how unfair is it that some people will become neighbours to a new waste management facility and/or its transportation corridor. These perceptions can then be tested against the reality of what is planned, the various impacts can be assessed and a list of mitigating and compensatory items can be developed for review by those affected. The willingness of the beneficiaries to compensate those negatively affected is a key element in working out an equitable conclusion.

4. Perceived risk management can be best achieved by an ongoing public information program so that those interested are knowledgeable about waste management issues affecting their area and others have ready access to understandable information when they seek it. Occasional newsreleases, inserts in water bills, programs in the schools and other low-key, low-cost methods can be used with the general public; meetings with special interest groups will update them on developments in the nature and volume of waste, the capacities of current facilities and the development of future requirements.

5. Technological education can limit public misconceptions about the value of alternative technologies by using a similar program of public education to that outlined above (#4). In one recent case, incineration was hailed as a superior technology until people came to understand that stack gases could contain potentially harmful contaminants.

6. Professional management can obviate the problems of management by crisis and schizophrenic management noted earlier as barriers. This requires long and medium range planning for waste management so that crises do not occur without the time needed to resolve them. Project managers also require management training, including the integration of public participation into the project management process.

7. Integrated planning, which includes all the various publics and parties to an issue, can help prevent polarization by breaking the we-they dichotomy. The planning workshop (7) is one technique which accomplishes this objective and develops creative solutions and workable compromises amongst the participants. Avoiding a war of words in the media is particularly important to prevent polarization.

8. Personal management, where the principals of the major organizations involved make and maintain personal contact in working to resolve a waste management issue, is an antidote to overlegalization.

If an effective and informal (8) network of interpersonal relationships is developed and maintained, problems can often be resolved directly and the legal procedures can be completed faster and with less conflict. Environmental mediation (9) is another useful approach.

9. Multi-level information, where technical information is available at three levels, overcomes the barrier of technical information overload. For example, technical documents are placed in a reference centre, like a local

library, for the interested professionals in the community; a partial summary and simplification of these papers is distributed to interested leaders of voluntary organizations; a newsrelease is prepared for the media to use in presenting the issues to the general public. At each level, key questions are posed and public response is invited.

10. Organization development, including an appreciation of the organization's culture (10), is a standard method of identifying and addressing cultural gaps between the organization and its external environment. Training programs associated with management programs, e.g. "Toward Excellence" (11) can revivify an organization and renew its links to its environment. (12) Another useful strategy is to compare community profiles with that of the proponent organization and note what gaps need to be bridged.

This section has provided one or more approaches for overcoming the ten barriers to public acceptance of waste management facilities identified initially. The following case study indicates how these issues were dealt with in a recent major project.

A CASE STUDY

The Lower Mainland of British Columbia encompasses a geographically and economically defined regional community stretching from the Strait of Georgia to the Coastal Mountains. It includes the three regional districts of Greater Vancouver (GVRD), Central Fraser Valley, and Dewdney Alouette and has a population of about 1.5 million people. (See map.)

In October 1983, the three Lower Mainland regional districts and their 21 constituent municipalities decided to develop a cooperative solid waste management plan. The Lower Mainland Refuse Project (LMRP) was established in order to find ways of handling the million tonnes of solid waste produced each year in the area.

One unique feature of the LMRP was the prominence of its public interface program. Solid waste management had been a volatile issue in the lower mainland for a decade, following the GVRD's various attempts to locate facilities in several different suburban municipalities and a private sector proposal to barge it to an island up the coast. Most technical specialists and politicians recognized that if a workable plan was to be devised, the public had to be involved from the outset.

Representatives of some 20 key public and special interest groups (e.g. The Society for the Promotion of Environmental Conservation (SPEC), The Chamber of Commerce, Don't Dump on Delta) were invited to participate early in the process. It is estimated that, in total, over 4,000 citizens in the Lower Mainland became involved in the LMRP over the eighteen month process.

A Crisis Situation

Before the LMRP was initiated in 1983, most municipalities in the GVRD faced an imminent crisis in the area of solid waste management. Several landfills were due to close and a number of others were reaching their capacity.

Responding to this crisis situation, the GVRD investigated three potential landfill sites to serve the municipalities of the lower mainland. One of the sites was in the municipality of Langley, one was north of the municipality of Pitt Meadows, and one was the private sector proposal on Texada Island some 50 kilometers north of Vancouver. In each instance the GVRD received strenuous opposition to the proposals, and the viability of establishing a landfill at any of the proposed locations became questionable.

In the meantime, solid waste management problems in the less populous Central Fraser Valley and Dewdney Alouette Regional Districts were of increasing concern to local authorities. Most landfills were facing imminent

capacity limitations, a problem accentuated by the fact that both regional districts anticipate significant population increases over the next 20 years.

Thus, the B.C. Minister of Environment invited the chairmen of the three Lower Mainland Regional Districts and the mayors of the constituent municipalities to meet and discuss how to best resolve the pressing problem of handling the region's solid wastes. There was unanimous agreement among the mayors that a comprehensive solution was needed. As a result, the LMRP was established to formulate a Waste Management Plan encompassing the Greater Vancouver, Central Fraser Valley and Dewdney Alouette Regional Districts. It was agreed that the plan would ignore jurisdictional boundaries within the study area.

The management of the project occurred through a Political Steering Committee (Chairman: Ministry of the Environment; members: 21 mayors and chairmen of three regional districts); and a Management Committee of senior provincial and regional district officials reporting to the Political Steering Committee. The project manager reported to the Management Committee.

Consulting engineer Keith Henry, was hired by the Management Committee as project manager. The technical studies required for the project were to be carried out by the staff of the municipalities and regional districts involved. The work was done by eleven working committees organized to address specific issues such as landfills, incineration, resource recovery and recycling, economic strategies, transportation and transfer stations.

Following a management directive that public participation be an early and continuous part of the project, Connor Development Services Ltd., a team of consulting sociologists, was retained to design and manage a public information and participation program. The project manager emphasized the need for full participation in all aspects of the planning process. This was particularly important for two reasons. First under the B.C. Waste Management Act, the Minister of Environment can only approve a plan if he feels there has been adequate public consultation. Second, once a plan is approved, the Act provides no mechanisms by which the plan may be appealed.

Public Program Objectives

The objectives of the public interface program for the LMRP were:

1. To provide an opportunity for the general public in the study area to realize their stake in refuse disposal, obtain information about it and contribute their views and suggestions in systematic and positive way.
2. To encourage relevant interest groups to become informed and involved in a constructive and consultative process.
3. To demonstrate how a positive public interface program can be developed in a waste management planning process without compromising the roles and responsibilities of final decision-makers.

Public Interface Activities

In order to achieve the above three objectives of the public participation program, the following activities were conducted:

Social Profiles. The first task of the program of work was to prepare social profiles of the three regional districts in the lower mainland to provide overviews of the communities involved. The profiles provide a social data base on which to design and manage the public program; they also initiated contact with interest group leaders and demonstrated that the project intended to take community concerns seriously.

Completed in a month, the three forty page reports described the historic events, demographic characteristics of the residents, key leaders, important groups, local issues, communication channels and, especially, what people knew and believed about waste management options and solutions.

The last disclosed that:

* Most people favored more emphasis on waste reduction, source separation of refuse, and increased public education on recycling, resource recovery and waste reduction.
* Thermal reduction of refuse and recycling and resource recovery were the preferred disposal methods, although some combination of methods was recommended.
* Most respondents suggested that the volume of refuse going to landfills should be reduced.
* Most people were willing to contribute financially and through individual recycling efforts to achieve a more environmentally sound waste management program.

Public Membership on Technical Committees. Numerous working committees were established by the Project Manager to prepare parts of the waste management plan. Representatives of public interest groups were recruited to participate on these committees alongside technical specialists as full working members. As a result community concerns were clear from the outset of technical analysis; later the participating interest group leaders could assure others of the methods used to reach recommendations.

Hot Line. An information telephone line with a tollfree long distance feature was established at the beginning of the project. About 15 to 20 calls per day were received on the Hot Line and a trained member of the LMRP staff was available to answer questions and provide accurate information, and establish a mailing list which ultimately numbered more than 500 persons and groups. A log of calls enabled issues and areas of concern to be monitored and documented.

Most people did voice their concerns and views which were passed along to the project manager and the project team. In this way project staff were kept informed about the immediate concerns of interested and affected lower mainland residents.

Responsive Publications and Information Centres. A general brochure outlining the scope and purpose of the LMRP was widely distributed early in the project. It included a mail back post card so that interested citizens could submit their comments and opinions about different waste handling methods and sites.

Technical reports were published and made available to the public through 13 information centres which were established at libraries, municipal halls and environmental group offices. A policy was established at the beginning of the project that all documents used and generated by the LMRP would be available for inspection by the public.

Open Houses. In January 1984 the first round of open houses was held with meetings in seven communities around the lower mainland. Two more series' of open houses were held during the LMRP, one to review the results of an LMRP Report outlining the solid waste options, and the other to review and obtain feedback on the Draft Solid Waste Management Plan. Special previews were held for elected officials and senior government officials.

More than 1500 people attended the Open Houses over the three phases and some 300 questionnaires were completed by those who attended.

Planning Workshops. Seven workshops were held to share technical information with a core group of about 20 public interest group leaders. An equally important purpose of the workshops was to obtain feedback from the participants regarding the social and environmental acceptability of various waste handling options. Meetings occurred about every six weeks throughout the project.

The groups represented included regional groups such as B.C. Recycling Council, West Coast Environmental Law Society, and B.C. Public Interest Research Group, while community based organizations included Surrey/Langley Residents Against Garbage (SLAG) and Fort Langley Community Improvement Society.

Newsletter. To keep interested members of the public informed about the progress of the LMRP, a four page Newsletter was distributed by mail and at libraries and other community facilities. The newsletter included articles expressing various points of view, including positive and negative reactions of group leaders who attended the workshops. Five issues averaging 2500 copies were printed and distributed.

Conferences. Two conferences were held in downtown Vancouver toward the end of the project to review the Draft and Recommended Solid Waste Management Plans respectively. Over 500 representatives of public interest groups, regional and municipal government, and private industry attended the Conferences.

Budget. This comprehensive and systematic program of public information and consultation accounted for more than 50% of the project budget. The public program cost some $127,000 over its 18 month duration.

Evolution of Understanding

Initially there was a good deal of skepticism by environmental group leaders about the assumptions and motives of the waste management engineers and vice-versa. The function of the first workshops was to dispel stereotypes and begin a mutual education process by which the various parties would understand each other's points of view and perhaps adapt their own.

A key event was the acceptance of an environmental group leader as a working member of each technical task group formed on Landfills, Thermal Reduction, Recycling and Transportation and Economics and other topics. Other members were usually 5-7 municipal, provincial and federal waste management engineers.

These engineers, including the project manager, started with traditional assumptions that landfilling was currently the cheapest and best method of refuse disposal and the contributions of recycling and incineration, while desirable, were still impractical and costly. However, as the project continued, the importance of waste reduction, separation at source, and recycling gained recognition, as did the merits of incineration. The Political Steering Committee endorsed a lesser role for landfill during the later stage of the project. The final report of the project manager supports waste reduction, recycling and a major program of incineration with the objective of ending the landfilling of raw waste within 10 years.

When specific potential landfill sites were designated towards the end of the project, new interest groups formed and were invited to join the planning workshop series. Initially, they were very skeptical and some remained so.

On a more positive note, the principal workshop participants formed the Lower Mainland Waste Management Coalition at the conclusion of the LMRP in order to promote the cause of better waste management in the region.

Summary of Public Response

The main themes from all sources of public comment are:

* willingness to pay more to ensure that solid waste is handled in an environmentally and socially acceptable manner;
* widespread support for recycling and waste reduction through incentives, education and research and development;

* support for modular incineration, provided that pollution control measures are adequate and monitoring is effective;
* opposition to the continued use of landfills as the primary method of disposing of untreated waste;
* support for decentralized waste management programs and methods, with shared responsibility for treatment and disposal.

Conclusions

An overall evaluation of the public interface program has not been completed. However, it is possible to make some observations about the two questions raised at the beginning of this article. Can governments and the public work together to develop a viable solid waste management plan? Can this cooperative process be conducted in a systematic and cost- effective manner?

A positive answer seems justified based on comments by participants in the LMRP on the recommendations contained in the final report, on the continuing active public interest by group leaders in pursuing the completion of a solid waste management plan and on the content of recent planning initiatives.

LMRP a Credible Process. The initial skepticism expressed by many individuals during the early phase of the LMRP was replaced by a widespread belief that the process placed a high priority on public involvement and that it offered real opportunities for the public to obtain information and to participate in the outcome. The LMRP achieved this credibility by instituting a continuous dialogue with the public from the beginning and by following an open-information policy. As noted in an earlier section, there were a variety of participatory mechanisms available to the public. These allowed persons and groups the option to become involved in a manner that was consistent with their time, expertise and interest in solid waste management.

While less than half of one percent of the total population took advantage of these opportunities, all were given several accessible options. Those who did become involved were usually the kind of individuals and groups who seek to shape public policy. If denied reasonable access, they often mount such vocal opposition that projects are delayed, discredited or halted indefinitely.

Throughout the LMRP, regular installments of information were distributed widely. This information not only presented progress reports; it provided a forum where dissenting viewpoints could be published and thereby escaped negative perceptions of being merely a public relations service. The LMRP dealt openly with criticisms, as evidenced by the fact that a document prepared by several key interest groups which was critical of some aspects of the LMRP was published and widely circulated by the project.

Public Input Influences Plan. Many persons involved in the LMRP perceived that the Project Manager's recommended solid waste management plan was highly responsive to public input. The emphasis of the plan on waste recycling and recovery, and the de-emphasis on landfills, provided a basis for much common agreement and widespread support. This represents an almost 180° shift from the situations prevailing when the project commenced.

Epilogue - The Politics of Waste

Since the final report of the project was completed, the following events have occurred:

1. The Management Committee refused to endorse the Project Manager's Recommended Plan and presented a report of its own calling for greater

reliance on traditional landfills and reduced emphasis on resource recovery and waste reduction. This was a substantially less costly proposal.

2. Several NIMBY (Not in My Backyard) groups successfully put pressure on their provincial M.L.A., who is also a Cabinet Minister, to have provincial approval withheld for landfills proposed in their area. This hamstrung both proposed plans and lead to dissension amongst the participating municipalities.
3. The Minister of the Environment did not convene a meeting of the Political Steering Committee - the 21 mayors and regional district chairmen who had initially endorsed the project and agreed to ignore internal jurisdictional boundaries. This left the project report in a political vacuum. The fact that the original plan has not been adopted, nor is it likely to be adopted in its original form, has caused many persons to reserve their judgement on the effectiveness of the LMRP.
4. The GVRD has authorized a 210,000 ton per year energy-from-waste project and has called tenders for resource recovery plants which it feels are needed in the immediate future. Meantime, several of the District's major constituent municipalities have explored establishing their own waste management authorities and operations.
5. A number of the key interest groups which had supported the LMRP formed a Coalition to promote better waste management in the Lower Mainland.

Recently, efforts to resume solid waste management planning activities have been initiated. Early indications are that these initiatives will follow through with many key recommendations of the LMRP and that public participation will remain a key part of the process. This suggests that the LMRP succeeded in shifting the attitudes of local government to provide more support for recycling and resource recovery. It also appears that public participation in the solid waste management process has been legitimized and is now welcomed.

We conclude that the LMRP provided a process where local government and the public could work together to develop a solid waste management plan in a cooperative and non-confrontational setting. It remains to be seen whether a workable plan can be developed, and whether the investment in public participation will provide a cost-effective resolution to the region's solid waste management issue.

Based upon the current situation, there is reason to be optimistic that the legacy of the LMRP will be a long-term, environmentally sound and socially acceptable solid waste management plan. If this is the case, then the public controversy that has clouded solid waste disposal plans for the last decade has indeed been resolved in a cost-effective manner.

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SUCCESSFULLY SITING HAZARDOUS WASTE MANAGEMENT FACILITIES

Environmental Elements Corporation

Thomas L. Rinker

Paper unavailable at time of printing

THE IMPACTS OF WASTE DISPOSAL FACILITY ON RESIDENTIAL COMMUNITIES: A PERSPECTIVE FOR RESEARCH

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ABSTRACT

The impacts of waste facilities result in an excess of losses over gains to the host-community residents. In this paper, criteria for the selection of remedies and incentives are developed in order to reduce the losses to the host-community residents and thereby achieve facility acceptance.

In order to identify the losses, a typical siting scenario is described in terms of the characteristics and the development pattern of facility host-communities. Then, the facility impacts are derived from siting case studies for municipal waste landfills and incinerators, and hazardous waste landfills. The impacts are classified as health effects, nuisances, environmental concern, and social impacts.

The second section examines residential property value differentials as a summary measure for the facility impacts. But empirical evidence indicates that property values are not a consistent measure of impacts and, hence, are not likely to be a reliable tool for compensating host-community losses.

The alternative approach to selecting incentives for the host-community is derived from the prospect theory. Since losses outweigh gains in value, it is better to minimize the losses by reducing the waste stream, preventing and mitigating the impacts than to compensate lost benefits with alternative benefits.

If the host-community is convinced that the best available technology is being applied, and that the technology and the regulation are sound, then compensation schemes may be successful in achieving host-community acceptance.

The ongoing research to test these hypotheses is described in the last section. The research comprises the identification of typical site, facility and community characteristics, the development of reduction, prevention, mitigation, and compensation measures, and the negotiation of acceptable sets of incentives with the host community residents.

INTRODUCTION

One of the most serious problems for planners, engineers, and politicians consists of achieving public acceptance of a waste facility in the host-community, because the facility causes negative impacts, and hence losses to the host-community. The losses must be eliminated to achieve community acceptance. In order to select successful remedies and incentives, the host-community and the facility impacts are identified and described.

SITING SCENARIO

The typical siting scenario for solid waste facilities serving large metropolitan centres usually fits onto the characteristic pattern for development of the host-community:

- The new sites for waste disposal facilities are usually on or slightly beyond the urban fringe, in agricultural or rural-residential areas. These areas are often unincorporated, low-density communities. Hazardous waste facilities are likely to be located somewhat farther from urban population centres. Industrial areas are the next most frequent location for waste facilities, particularly for incinerators.
- The sitting residents, i.e., those living in the host-community before the facility is proposed, are very sensitive to detrimental changes in their community. Noxious waste disposal facilities are seen as particularly harmful, not only because of their physical impacts, but also because they signify the imposition of "urban" industry and waste on the community's rural way of life (Bealer, Martin and Crider, 1982).
- The host-community ultimately is caught up in the urban development and experiences rapid development because of the community's advantages relative to other locations, e.g., because of its distance from the urban core. As a result, the areas directly adjacent to the waste facility are often developed and attract new residents. The character of the community changes with the influx of new residents from a rural-residential to a suburban middle class community.
- Initially, the new residents are not as well informed, or as sensitive to the waste facility impacts as the original set of sitting residents, because the new residents having not been sensitized to the new impacts by having the new facility imposed on them. In contrast to the sitting residents, the new residents can be assumed to derive some overall benefit from moving into the host-community, even in view of the facility impacts. If evident impacts are subtle, then the opposition of both sitting and new residents may decrease with time. However, as the new residents become fully aware of the scope of the impacts, or if the size or expected life of the facility are increased, the new residents may become more strongly opposed. If annoying impacts persist, sitting and new residents alike will resist the operation and presence of the facility.

The graph in Fig. 1 shows the development of densities and property values in the host-community.

The development is often induced by the growth of the urban centre and the resulting accessibility of the host-community to employment and services in the metropolitan area. These effects result in higher property values, the prime motivation for development in the host-communtiy. Clearly, the advantages in accessibility tend to offset the negative impacts caused by the facility.

The losses in the host caused by the facility are numerous and varied. They will tend to increase, because the number of people affected grows. Moreover, the size of landfills and the capacity of the disposal facilities may increase too.

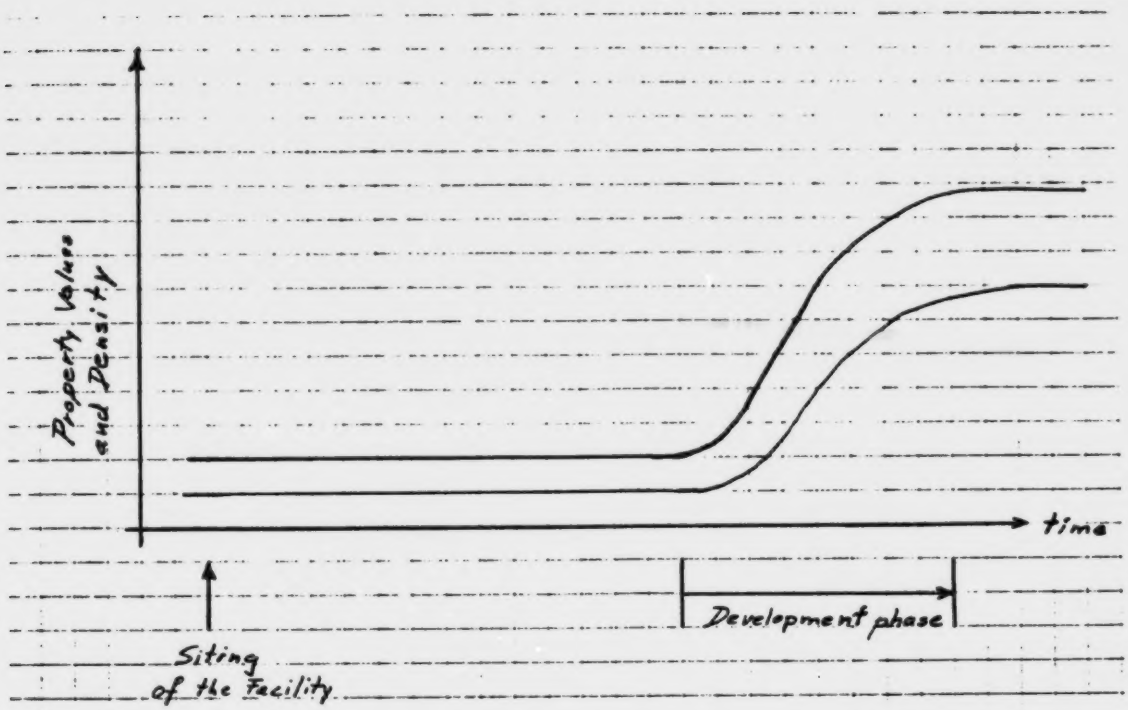

FIGURE 1: DEVELOPMENT OF HOST-COMMUNITY DENSITIES AND PROPERTY VALUES AFTER FACILITY SITING

FACILITY IMPACTS

The analyses of numerous facility siting processes (Centaur Associates, 1979, O'Hare, 1983, Zeiss, 1984 and others) have identified the external impacts of municipal and hazardous waste landfills and of municipal waste incinerators. These impacts are summarized here under four categories:

- Health effects comprise all events, risks and uncertainties that may affect human health;
- Nuisance effects include all impacts that disturb the peaceful enjoyment of residential land use without endangering human health, e.g., noise, odors, visual disamenity, etc.;
- Environmental effects comprise all impacts that do not directly affect human residential use, but impact on the general environmental quality, degrade the environment, or decrease available resources. In general, the perception of "waste" seems to adhere to this category;
- Social effects decrease the prestige of the host-community because of the stigma attached to "waste" facilities, the demoralizing effects of having losses "unfairly" imposed on the host-community, etc.

The matrix below identifies the positive and negative impacts by type of facility.

TABLE 1: WASTE FACILITIES AND THEIR IMPACTS

	MSW Landfill	MSW Incinerator	HW Landfill
Health			
water pollution	x		xx
air pollution		xx	x
risks/uncertainties	x	x	xx
Nuisances			
odor	x		xx
noise	x	x	x
visual disamenity	xx	x	x
Environmental Concerns			
"waste"	xx	x	x
habitat destruction	x		x
Social Impacts			
stigma	x	x	xx
unfairness	x	x	xx
loss of control	x	x	x
Benefits			
land reclamation	x		(x)
energy	(x)	x	
materials		(x)	(x)
employment	(x)	(x)	(x)
disposal service	x	x	x

Two basic conclusions evolve from the matrix: the general lack of strong benefits accruing specifically to the host-community, and the significance of the general environmental and social impacts caused by the presence of waste facilities.

1. The lack of apparent benefits to the host-community is typical of many waste facilities, although the provision of the disposal service itself is a valuable function. However, this benefit accrues to all waste generators and is therefore not a specific benefit to the host-community residents.
2. A strong, negative social stigma adheres to "waste" in western society (Crider, Martin and Bealer, 1982). All physical impacts are therefore negatively loaded with the significance of the socially undesirable stigma. Moreover, the feeling of helplessness, loss of control, and the unfair distribution of losses and gains have been identified as demoralizing impacts on host-community residents (Madisso, 1986, Michelman, 1967).

Finally, it becomes evident from the numerous intangible impacts (health, nuisances, etc.) that there is no simple method of measuring the losses or compensating them in simple, monetary terms.

IMPACT MEASURES AS A BASIS FOR ELIMINATING LOSSES

This section reviews residential property values as a summary monetary indicator for facility impacts and derives a principle for selecting reduction, prevention and compensation measures to eliminate losses to the host-community and achieve voluntary acceptance.

A. Residential Property Value Differentials as a Summary Impact Measure

Residential property values are often cited and used as indicators for the negative impacts from airports, highways and other undesirable facilities (see, e.g., The Report of the Commission on the Third London Airport, Roskill, 1971).

Property value differentials are an indirect method of measuring externalities, because they value the average response of the individuals in the marketplace to the entire package of residential enjoyment obtained by purchasing residential property.

The value of residential property reflects the expected yields of peaceful enjoyment to the owner or tenant. The value of a residential parcel consists purely in the scarcity of the characteristics of the parcel, i.e., the advantage of the parcel in location, amenity, or any other attributes that are desired by prospective buyers.

Because the market price reflects the value of the expected future stream of benefits, i.e., of residential enjoyment of the property, it includes any expected changes to this stream in the future. Thus, if quiet homes are expected to become more noisy, then their value compared with presently noisy homes will decline (Mishan, 1982). The expected future yields are converted into the present worth with the applicable discount rate so that the market price reflects the sum of the properly discounted future yields (Knetsch, 1983).

From the statement above follows that any changes that affect the enjoyment of the property as perceived by the owner or occupant, will diminish the capability of the property to produce the expected yields. However, the loss will only carry over to the next owner if he or she is equally or more sensitive to the effects. The market price declines only if a significant number of people in the market perceive the effect to be undesirable.

The advantage of market price differentials consists of the summary measurement and weighting of all effects as perceived by those persons in the marketplace with the highest reservations value (Schmalensee, 1975). This postulate implies that only those impacts that are perceived by the prospective buyers are valued, whereas long-term and insidious effects do not enter the valuation (Freeman, 1979), nor does any special, or sentimental value to the owner (Knetsch, 1983). Psychological effects such as risk, uncertainty, and stigma will be reflected insofar as they are perceived by the prospective buyers before the purchase. Thus, the property value differences between affected and unaffected parcels provide in theory a simple summary dollar measure of the external effects perceived by the potential buyer.

A review of property value studies around waste disposal and other undesirable facilities shows somewhat contradictory results.

- Havlicek, Richardson and Davies (1972, in Schmalensee, 1975) used distance and angle from the downwind direction as independent variables on the MLS (Multipe Listing Service) sales prices to achieve a total explanation of variation of 79% and showed a significant correlation.
- Goldberg (1972, in Schmalensee, 1975), used distance and visibility to explain the percentage change in property values over time. Although results were insignificant, it is not clear why the change in property values was chosen as the dependent variable, because there is no apparent reason why this dependent variable should differ significantly for affected and unaffected parcels.
- Schmalensee et al (1975) studied properties around four landfills in California and found only marginally significant correlation between distance and property sales prices. No significant effects on appreciation or residential development near the site was observed.
- Hockman et al (1976) studied 55 landfills in Chicago SMSA and 15 incinerator sites using distance and angle from the predominant downwind direction to estimate property sales prices. The results were significant and indicated impacts of landfills extending over three city blocks, equivalent to 6 to 7 cents per ton. Incinverator effects extended 20 city blocks and amounted to $1.70 per ton.
- Groth (1981) studied the effects of five landfills in California, Oregon and Washington on property values, appreciation rates, land-use patterns, and rents. Only few and marginally significant effects were observed.
- Gamble and Downing (1984) found significantly lower property values near landfills as compared with control areas, but the effects were not confirmed in a correctly specified hedonic price model, except for those parcels on the main access road, where a statistically significant effect was found. However, the expectations of residents that the landfill site will become a park were mentioned as an explanation for the lack of a significant effect. Furthermore, people may offset the lower property values by constructing more expensive homes.

Studies of similar, or supposedly more noxious facilities show ambiguous results.

- Blomquist (1974) found significant correlation of property value differentals within 11,500 feet (= 3 km) of the Winnetka electrical utility power plant in Illinois. The differentials were best fitted by a linear function with a 0.9% decline for every 10% decrease in distance to the plant.
- Nelson (1981) studied the sales prices before and after the Three Mile Island accident in 1979 and found no significant differences in property values or in appreciation rates within the 20 mile radius of the plant. However, other possible explanations for the lack of effects were identified:
  - clean-up workers may have taken up the slack in the market;
  - the observation period after the accident was only 9 months; this may have been too short for the price level to adjust;
  - the expectation of federal and state assistance may have kept the property values at par with other areas;
  - the lack of any damage from the accidental release and the prompt clean-up may have resulted in merely short-term costs of evacuation and anxiety to the residents.

- Gamble and Downing (1982) studied property sales around four nuclear power plants in the Northeastern U.S. Both linear and log-linear functions relating plant visibility and distance to the property values showed no significant correlation. Moreover, 583 single family dwelling sales in a 25 mile radius from the Three Mile Island site and 112 sales in a control area were analyzed, but showed no significant effects. However, the analysts hypothesized that the plant closure during the study period may have delayed the effect on property values. This study attempted to assess the impact of clean-up workers moving into the area and found no effect.

Overall, property value differentials do not consistently reflect the anticipated effects on the value of residential property. Although this finding is counter intuitive, there are (apart from others) four crucial assumptions which may be violated in the case of waste facilities:

1. Perfect information is a prerequisite for buyers and sellers and is assumed to comprise the knowledge of the going price levels for amenities and of the complete set of attributes of the property. Not only must buyers be aware of the impacts, but they are assumed to be capable of appreciating the impacts in advance of living in the community. It is questionable if buyers can be aware of all possible impacts after viewing the properties for a brief and limited period before making an offer. The necessity and the existence of building codes is an important indication of the weaknesses of the "perfect knowledge" assumption.
2. The buyers of the affected units may be less sensitive to the noxious effects than the original residents. Thus, the shift in the average sensitivity to the impacts will reduce the market price differential, without decreasing the true social cost to the sitting residents. If all in-movers are completely insensitive to the impacts, then the resulting market price differential is zero.
3. The expectations of the buyers regarding the level of environmental amenity in the future may differ from those held by the sitting residents. The in-movers may expect the negative impacts to decline or cease in the near future, or they may expect other, similar communities to become affected by similar or worse impacts. Either way, these expectations result in higher market prices that do not reflect the losses to the sitting residents. If the buyers' optimistic expectations are disappointed by significantly higher impacts, then they will be confronted with value losses resulting from the more severe impacts. This is the typical case of misinformed in-movers (Abelson, 1977).
4. The affected community may possess offsetting amenities or locational advantages over comparable areas. Better accessibility to employment, schools, or other desirable features may offset the noxious impacts and result in little overall property value differential.

Some initial thoughts indicate that these vital assumptions may be violated:

1. Buyers may not spend much time looking at the neighbourhood or consulting with city officials, because they assume the location is safe due to the zoning and health regulations. They may have visited the property on evenings or weekends for short periods when noxious impacts may not be apparent.
2. Some buyers may be insensitive to the effects and may not care about the impacts.

3. Buyers may expect or hope that the facility will close soon and become a park or golf course, while sitting residents may believe the facility will operate for a long time.
4. The development in the host-community is caused by offsetting locational advantages relative to other areas.

Unfortunately, the violation of the assumptions precludes the use of property value differentials as a summary measure for the facility impacts. Therefore, a different method of eliminating losses to the host-community must be sought.

B. Acceptance Incentives

As concluded in the previous section, the lack of significant benefits to the host-community in connection with many negative impacts, causes the net loss. To eliminate the resulting losses, the siting agency can either decrease the net loss by reducing the impacts, or increase the benefits by compensating the host-community residents.

The following section develops a principle for the selection of monetary incentives for the host-community.

The criterion for selecting siting incentives is derived from the prospect theory (Kahneman and Tversky, 1979). The prospect theory states that a person's welfare depends on the evaluation of gains and losses from a reference point rather than on the absolute level of well-being. Although the reference point is not defined, there is strong evidence that losses from the reference point loom larger than equal gains. These relationships are contained in the "S" curve relating losses and gains to the resulting "value."

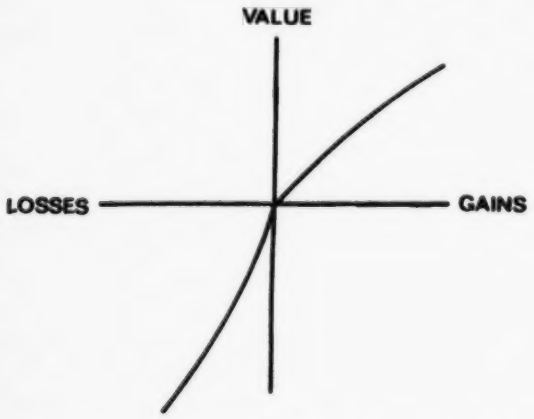

FIGURE 2: VALUE OF GAINS AND LOSSES ACCORDING TO PROSPECT THEORY: SOURCE: KAHNEMAN AND TVERSKY, 1979.

Therefore, it can be deduced that, in general, a reduction of losses will weigh more than an equal gain.

This conclusion should be applied in the siting process to select acceptable incentives under the following assumptions:

- The location of a waste facility is considered a loss to the residents, that is, the reference point for the sitting residents is the community without the waste facility.
- The overall loss consists of many different losses of (mainly) intangibles; since the dimensions are not evaluated in commensurate units, these losses cannot be evaluated or eliminated by a single measure, e.g., by money.

From the application of the prospect theory it follows that the degree to which a measure addresses the cause of the loss to host-community residents, will determine its effectivness in obtaining facility acceptance. Thus, it follows that the four specific approaches to achieving acceptance can be ranked as follows in terms of their effectiveness:

1. Waste stream reduction through separation and reuse of materials, e.g., through household or central separation will be most effective, because it substantially reduces health and nuisance impacts depending on materials and volume. Waste stream reduction also significantly decreases the perception of the "waste" of resources and generates materials and energy. Finally, it decreases the unfair distribution of losses to the host-community and benefits to all waste generators.
2. Prevention of impacts through the use of the best available technical control technology (e.g., through leachate containment and treatment) is likely to reduce specific types of impacts very efficiently, but does not reduce the "waste" or generate useful materials.
3. Mitigation of impacts through minimizing or reversing impacts (e.g., through the provision of emergency response teams) take effect only after the damage is done, and loss has occurred.
4. Compensation of the loss of one type of benefit with another benefit (e.g., money payments for putting up with nuisances or slight increases of health risks) does not address the specific impacts but provides alternative benefits for the losses. Therefore, unless the host-community has some salient alternative need (e.g., employment), the provision of alternative benefits for losses due to health risk, nuisance, social impacts are probably not going to be as effective as preventing the impacts in the first place. The exception to this rule applies if the compensation (e.g., money) can be used to obtain in-kind substitutes for the losses, e.g., a new residence in a community without a waste facility.

In summary, the most promising approach to host-community acceptance comprises three elements:

1. Absolute Contraints. The need for the disposal facility to the host-community must be proven and recognized by the host-community. Both the proponent and the regulating and enforcing government agencies must have good credibility with the host-community as a prerequisite for siting process. The proponent government must openly provide information early and must avoid any semblance of strategic maneuvering. Further, the proponent and the government agencies must be willing to negotiate with the host-community residents to avoid imposing the loss of control on the host-community residents.
2. Necessary Incentives. The lack of any significant benefits to the host-community requires that the losses be minimized before residents will consider compensation through other forms of benefits. Two criteria are proposed as prerequisites for acceptance:

1. The waste stream must be reduced and the impacts prevented with the best available technology (BAT) in order to reduce the various impacts on the host-community, regardless of the environmental standards and the cost of the control technology. Even with BAT, residual losses will accrue to the host-community. The general priority of impact reduction depends on the specific facility and the weighting of the impacts by the community.
2. The best available technology must be sufficient to reduce the impacts below health, safety and nuisance bylaw standards. This is a necessary but not sufficient requirement. If substantial social stigma remains, then even minor residual impacts will cause negative attitudes among host-community residents.

These two requirements reduce the losses imposed on the host-community. They are necessary, but not sufficient conditions for facility acceptance. From the host-community residents' perspective any impacts, even residual effects, are losses from their reference point (the community without the facility). Thus, additional incentives may be required once reduction and prevention have been applied to minimize facility impacts.

3. Desirable Measures. A large number of possible additional measures to mitigate and compensate the residual effects can be grouped into unconditional and conditional measures. Unconditional measures (such as the provision of emergency response teams) are provided regardless of any specific events or consequences. Conditional measures (property value guarantees) come into effect if some event or damage occurs.

These measures can be used to offset residual risks, uncertainties and strategic effects. These incentives must, however, be aimed specifically at the cause. Mitigation measures will be more effective than compensation, because they reduce the losses, rather than providing gains on other dimensions.

In summary, the success of an incentive package in the context of waste disposal facilities depends on the prevention of losses through waste stream reduction and technical pollution control with the best available technology, and second, comprises mitigation and compensation measures to offset residual and strategic impacts. Under no circumstances will the residents be "bought off" for money compensation unless the funds can be used to address the problem. For example, if monetary compensation is sufficient to allow affected residents to move to an alternative community, then they can avoid the impacts.

ONGOING RESEARCH

In order to test the effect of the incentives on the facility acceptance, three steps will be carried out in the next year:

1. "Typical" facility, site, and community characteristics will be established in the study area (Pacific Northwest of Canada and the U.S.). The variables comprise three categories:
   a) Site characteristics, e.g., soils, climate, vegetation, topography, etc.
   b) Technical design and operation, e.g., type of facility and waste stream, emission controls.
   c) Community characteristics, e.g., surrounding land uses, type of community, property values, employment, growth pattern, etc.

TABLE 2: THE EFFECTS OF ACCEPTANCE INCENTIVES ON FACILITY IMPACTS

	Incentive Measures				
	Contraints	Reduction	Prevention	Mitigation	Compensation
IMPACTS					
Health					
water poll.		x	xx	x	
air poll.		x	xx	x	
residual risks					x
uncertainties					x
Nuisances					
noise		(x)	x	(x)	
odor		(x)	x		
visual impact		(x)	x	(x)	x
traffic		(x)	X	(x)	
Environmental Degradation					
waste		xx			
habitat		(x)	x	(x)	x
Social Impact					
stigma		x			(x)
unfairness		x	x	(x)	x
control/ victimivation	x				
need	x				
BENEFITS		x			x

2. The consequences of incentive measures will be determined in terms of the disposal costs and the reduction of the impacts. In particular, the site dependent variables will be identified. The results will be presented as ranges to identify the variation between sites.
3. The effects of the incentives in achieving acceptance among host-community residents' groups will be tested in negotiations with the group's representatives at the study sites. Negotiations will allow the transfer and verification of information about known facility impacts in a defined community. The goal is to establish the residents' response to the incentives and the set of incentives necessary to achieve acceptance.

SUMMARY

Waste disposal facilities generate a wide range of negative impacts comprising health risks, nuisances, general environmental concerns, and social impacts. The negative impacts of waste disposal facilities outweigh the positive effects and result in an overall loss to the host-community.
In order to gain community acceptance, it is necessary to reduce the losses to the host-community. Therefore, the losses must be identified and measured to select suitable reduction, prevention, mitigation and compensation measures.

Residential property value differentials are not reliable summary indicators of the losses, because certain losses are not reflected in property values and because some of the critical assumptions of the property value model are not fulfilled.

This paper derives from the prospect theory the hypothesis that, in general, it is more effective to reduce the losses to the host-community by reducing the waste stream volume and its contaminants and by preventing and mitigating impacts by technical measures than to compensate one type of loss with an alternate type of benefit. It is furthermore necessary to minimize the losses to the lowest level technically possible, and at least to the regulated levels, if acceptance is to be achieved at all. Only then will the host-community consider compensation for the remaining residual impacts, providing the residents are convinced that the control technology and the regulations will ensure a low level of risk and exposure.

In future research, this basic principle will be used to identify realistic reduction, prevention, mitigation and compensation measures in terms of their monetary costs and their reduction of the facility impacts. Finally, the basic principle will be tested in negotiations with host-community representatives.

ACKNOWLEDGMENTS

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YES! IN MY BACKYARD - MANAGING SPECIAL WASTES IN ALBERTA

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Alberta Special Waste Management Corporation

THE WASTE MANAGEMENT PERSPECTIVE IN ALBERTA

The siting of a hazardous waste treatment facility near Swan Hills, Alberta, has generated disbelief, curiosity, and amazement among waste managers. North American experience has brought meaning to the term 'NIMBY' - Not In My Backyard. Citizens and politicians may agree that waste handling facilities are necessary for the maintenance of a clean and safe environment, but they feel they should be located 'somewhere else'.

Alberta's siting program was successful; but it was not without hard work, long hours, many miles travelled, and an intense but sensitive approach to the broad spectrum of waste management. The approach to siting is reflected in the implementation plan to involve the public to the fullest extent; to integrate the theoretical and practical procedures for waste collection, treatment, and disposal; and, to continue the government's role as facilitator to ensure responsible pollution control resulting in a maintenance of environmental quality and human health.

Established systems in Scandinavia and Europe are examples of proper waste management encompassing collection, transfer, treatment, and disposal operations. The addition of recycling and resource recovery has resulted in integrated networks in which industry and the public participate. Setting such systems as workable examples for Alberta has allowed the government, municipalities, waste generators, and the public to assess their requirements and define local, regional, and provincial programs.

The Departments of Environment and Social Services and Community Health, in conjunction with municipal and private operators, plan and manage the disposal of municipal waste in Alberta through a system of transfer stations and regional sanitary landfills. The special, or hazardous, waste management system is an extension of an already-functioning program. The basis of the special waste system's operation is public understanding of the need for waste handling facilities, and the citizens' role in ensuring that waste is not indiscriminately dumped. Public information, local involvement, and participation in the decision-making process have been key factors in the success of an integrated waste management system. This system begins with the householder and small generator; includes municipal waste collection, transfer and disposal in a sanitary landfill; encompasses recycling, reuse, and resource recovery; utilizes a controlled transportation network; and, provides a treatment and disposal plant for those organic and inorganic wastes which cannot be safely disposed of elsewhere in the system.

To date, one component in this system which has received most attention is the treatment and disposal facility. Its siting brought together the theory, skills, and practical application of environmental science, ecology, hydrogeology, land use planning, sociology, process technology, political science, and a wealth of research, patience, and the involvement of every level of government, industry, and society.

On March 12, 1984, the Minister of Environment for Alberta announced that Cabinet had chosen a location for the development of an integrated special waste treatment and disposal facility. Environmental requirements had been satisfied, and social assent had been gained from the people of the nearest town, Swan Hills.

This announcement was the culmination of an intensive province-wide site selection and public information program begun in 1980 by the government of Alberta. It was unprecedented in North America that a facility site had been volunteered, then selected based on environmental and social acceptablity.

The announcement not only marked the completion of a major siting program, but it also served as the beginning of a new and extensive program of project development along with a new direction in public involvement, technology assessment, site preparation, facility construction, transfer station planning, and special waste system management. Many government agencies have been involved and the private sector is an active participant in the building, ownership, and operation of the facility. The Alberta Special Waste Management Corporation has been established to oversee the system and ensure both continued human health and safety and the protection of the competitive position of Alberta's industry.

APPROACH TO SITING

Site selection has posed untold problems for governments and private developers in many countries for many years. It could be that hasty decisions are made or poor judgment is used in the way that plans are announced. If a siting decision is made prior to thorough investigation of a location, appropriate examination of other potentially suitable sites, or the disclosure of intentions to local citizens, then the project has a strong likelihood of opposition and failure.

There are many examples of excellent siting strategies which have been professionally produced and programs which have been technically accurate. Sites have been selected in a proven, scientific manner. However, not only has the necessary involvement of the public been overlooked, but the presentation of the rationale and assessment data has not been geared to the public forum. It is now clear that the technological aspects of site selection are standard and well known; it is the communications, sociological aspects, and citizens recommendations which need careful attention and inclusion in any program which involves such an emotive topic as special waste management.

The approach taken in Alberta's program transcended the potential pitfalls of such a contentious issue. Program planning, information gathering, and the compilation of results were conducted in such a way as to include input from local sources and all data were displayed and provided to the public in an easily-interpreted manner. If there is a lesson to be passed along from the Alberta experience, this is surely it - the public must be given the opportunity to become informed about waste management and to provide input to solve problems inherent in establishing necessary waste handling facilities. All information must be available, concise and clear. And, decisions, even though political, must reflect the public in-put. The Ministerial statement at the outset of Alberta's site selection program resolved that a waste treatment facility site must be environmentally suitable and acceptable to the local public.

The aim in any waste management program is for a site, operating procedure, and closure plan which are consistent with the protection of air, water, and ultimately, human health. The approach taken in Alberta considered a full range of constraints and applied these criteria to the long-term goals of the program.

SITE SELECTION TECHNIQUE

The essence of site selection is the elimination of all areas which do not fit criteria. This technique has a proven record and is widely used in resource assessment and site suitability studies for a broad range of land uses. Presentation of all data is streamlined through the use of base maps, overlain with a series of clear plastic maps on which colour-coded siting criteria are displayed.

A provincial perspective of Alberta was initially developed to provide a 'broad brush' view of potentially suitable regions. Maps at 1:1,000,000 were used and allowed for transfer of information on water systems, geology, soils, habitat, forestry, and historical resources. More refined regional assessments were then based on maps at 1:250,000 and coincided with transportation and resource inventory materials which provided excellent detail for 'fine tuning' and presentation of data at a scale which delineated individual land holdings. This scale also matched that used by the provincial land survey, which served as an accurate base map grid.

Data were derived from government and research agencies, and much use was made of the Canada Land Inventory. All data were readily available, but had never been compiled in such a way as to present a total picture of environmental suitability for industrial development.

Over the base map, which provided the legal grid, river systems, towns, and transportation routes, all other criteria were separately displayed in colour. As each sheet was placed over the base map, all areas of constraint compounded to give an overall view of blank or

constraint-free areas. This approach gives a comprehensive representation of all criteria which may affect a particular tract of land. Using graphics in such a way not only presents data in the context of neighbouring activities, but provides a vehicle by which public critique and comment can contribute to the planning process. Public participation was encouraged in 'building' the package and adding local refinements to the mapping. Attempts were made not to present perfect finished graphics to public forums, but in fact to allow individuals to assist with development of draft mapping systems during the actual discussions.

SITING CRITERIA

Guided by the need to protect environmental quality and preserve cultural values, siting criteria were developed for the delineation of lands which could be considered as candidate locations in the search for a waste treatment plant site. Four general categories were defined: physical, biological, land use, and human. This order follows a progression from the stable natural environment, through to the variables of ecology, to human activities reliant on bio-physical limitations. Social and cultural activities and values relate directly to the opportunities provided by environmental conditions.

Physical constraints were established to ensure that any waste treatment plant site was capable of containing a spill or leak. Alberta is fortunate in that glaciation has left behind a dense layer of till which, in many areas, is gravel-free and highly impermeable. All areas with significant gravel or sand lenses, fractures, or groundwater recharge were ruled out. To avoid possible contamination of water courses, all locations adjacent to surface water bodies or aquifers were similarly deleted. Steep slopes were avoided because of instability and difficulties of site preparation, construction and potential problems of runoff containment. Alberta's geology is not prone to seismic activity; however, some tectonic movements are recorded near the Cordillera, and induced activity is evident in areas of enhanced oil recovery. This criterion was reviewed for all candidate sites.

Lands with potential for productivity were eliminated from consideration. Regions with rich soil, merchantable timber, and important game and bird habitats were all avoided.

The interpretation of land capabilities has given Alberta a rich mosaic of prime farm land, valuable grazing reserves, ecological preserves, and vast tracts of renewable and non-renewable resource extraction. All federally owned land was eliminated, including National Parks, Indian Reservations and military zones. Transportation corridors were noted for future reference of access.

The preservation of culturally valuable areas was the most important aspect of the human resource criteria. Prehistoric and historic values were considered of great worth to the cultural fabric of the province, and, as such, were eliminated from siting. Intensive recreation areas are of

tremendous value both now and for the future. Population centres were highlighted, but did not classify as constraints. Rather, these points were deemed of interest as centres of public awareness and as concentrations of populations in need of a waste management program.

Following the siting mapping exercise, data were returned to each municipal council. Local public input was invited, and the community could then choose constraint-free lands for further consideration. These areas were then assessed in more detail than the original study. Up to this point, all work had been "academic" and depicted graphically. Site specific studies were then begun to:

1. confirm all data used in mapping;
2. gather information on site conditions of terrain, surface and ground water, soils, vegetation, and geology; and
3. put into place a series of monitors to provide data on long-term conditions and changes in the environment.

Within two years of program initiation, five candidate sites had invited detailed hydrogeological assessment with groundwater quantity and quality wells in place. All sites proved to be environmentally suitable prior to the final siting announcement in March, 1984.

COMMUNITY INVOLVEMENT

It is impossible to describe Alberta's site selection program without a full discussion of the public involvement which went hand-in-hand with the physical site assessment. Community involvement has been a cornerstone in the hazardous waste treatment facility siting program. Indeed, the process of providing information to the citizens of Alberta was begun before the site selection program was implemented.

The topic 'hazardous waste' has strong emotive powers. It can arouse deep-seated angers, frustrations, fears, and reactions against any level of government, all industry, and progress in the modern world. Irrational reactions can cause illness, depression, arguments, alarm, and wide-spread panic. Fear of the unknown, or distrust and lack of confidence in pollution control programs, can bring about vociferous opposition to hazardous waste facility siting plans. This is also a favourite issue with the news media, which promulgates much mis-information.

Citizen awareness and participation in the decision-making process is an approach which can result in calm, two-way communication between the people and the government, and permit an understanding of why a management system is needed, how it can be implemented, and what the undesirable and desirable impacts may be.

The approach taken by the task force from Alberta Environment assigned to the Special Waste Program was one of complete and open disclosure of all information gathered and derived for the facility siting process. Before any step was taken or plan implemented, the public were made aware of the

government's intentions. No studies were confidential, and no test results were kept from public scrutiny.

Understanding the subject of special waste is difficult for the layman, particularly if it is introduced suddenly and out of context. Recognizing this potential problem area was a major breakthrough in structuring an approach to the community involvement program. By presenting hazardous waste as a small, but important, part of the general waste stream, and by showing the local waste management practices, and problems, special waste became less an esoteric factor, and more a familiar, local, and expected part of the waste produced by any household, community, or industrial park.

Associating special waste management with the broader scope which includes waste reduction, exchange, and recycling also put the "problem" into perspective. Options for taking previously hazardous wastes out of the system and re-introducing them as products or feed-stock for other processes make environmental and economic sense. A display of how a network of waste management facilities might operate in the province proved effective in bringing all aspects of municipal, industrial and hazardous waste into focus. Graphic and print materials, audio-visuals, and other communications tools enhanced a personal approach and helped the varied audiences understand their role in developing an effective waste collection, transfer, transportation, treatment, and disposal network.

THE SITE

The chosen site lies some 20 kilometres (12.5 miles) northeast of the Town of Swan Hills, 200 km (125 mi) northwest of Edmonton in central Alberta (Figure 1). This is an area of dense glacial deposits overlain by muskeg and boreal forest. Climatic conditions reflect the high elevation and latitude with a long, cold winter and a short, warm summer. The site lies within a vast tract of government-owned land and has no neighbouring land users. The main activities in the area are oil and gas exploration and recovery, and lumbering.

The site consists of one half section, 129 hectares (320 acres), of land, of which 9 hectares (23 acres) make up the development site. A 0.8 km (0.5 mi) deep buffer zone surrounds the property. The buffer registration ensures that all adjoining land plans are first reviewed by the government, and all development plans for the site are reviewed by neighbouring land leasors.

This site is well suited for the treatment and disposal of special wastes. It is relatively remote, has no agricultural value, supports no prime habitat, has no potential for flooding, and encompasses no surface water systems. Most importantly, the hydrogeological conditions are ideal. Glacial till overlies the site to between 10 and 20 metres (30 and 60 feet), with an average hydraulic conductivity in the range of 10^{-7} cm/sec. This natural containment offers the ultimate safety factor against contamination in the event of leaks or spills of chemicals on the process area and in the landfill.

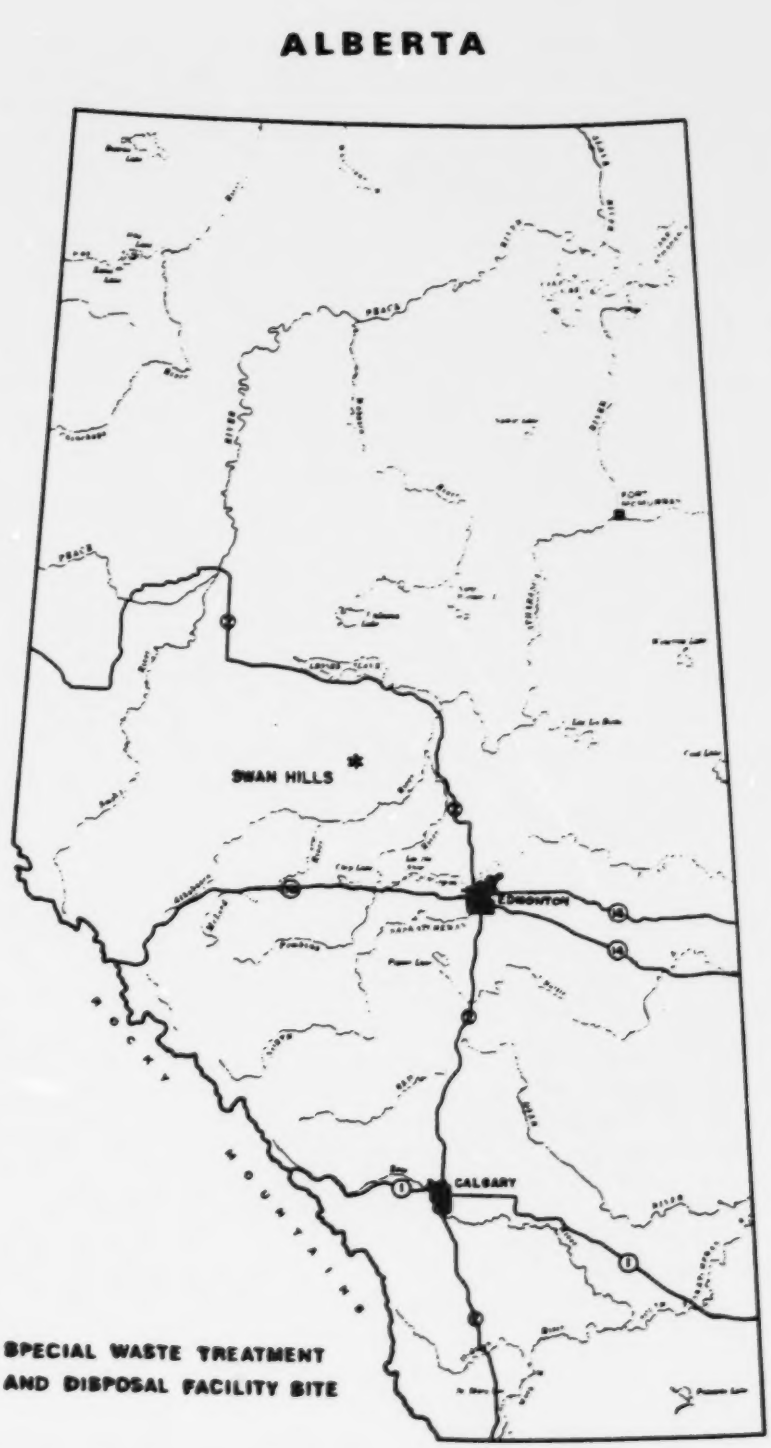

Figure 1. Location of Alberta's Special Waste Treatment and Disposal Facility

THE SWAN HILLS TREATMENT FACILITY

Construction of the treatment facility at Swan Hills began in August 1985, and start-up is planned for mid-1987. A Joint Venture between Bow Valley Resource Services Ltd. and the Alberta Special Waste Management Corporation is building the facility. Chem-Security Ltd., a subsidiary of Bow Valley Resource Services Ltd. is the operator. The plant has been designed for between 20 and 30,000 Tonnes of waste per year, with approximately 75% being organic. It will be integrated and comprehensve and will be capable of safely treating and disposing of any non-nuclear waste generated in Alberta. Major components of the facility are:

- high temperature incinerator for destruction of organic wastes
- physical/chemical treatment processes for inorganic wastes
- secure landfill for treated solid residues
- deep injection well for treated liquid residues and runoff
- infrastructure including laboratory and administration building, operations and maintenance building, waste receiving area, storm water collection ponds, sewage treatment plant, truck wash, drum handling and storage areas

THE CROWN CORPORATION'S ROLE

As a result of public hearings, and as part of the government's intended policy, the Alberta Special Waste Management Corporation was established on April 1, 1984 to oversee the implementation of a special waste management system for Alberta. Other key objectives of the Corporation are: to ensure the continued health and safety of Albertans, to ensure the role of the private sector in the waste management system, and to act as a facilitator between the waste generators, the public and the regulatory agencies of government.

The Corporation owns the property on which the plant is built and holds a reservation on the surrounding buffer zone. Also, the Corporation has provided all utilities to the site: electric power, natural gas, water, and telephone. Nine kilometres (5.6 mi) of access road to the site have been realigned and rebuilt.

Establishment of an integrated waste management system in Alberta, including a network of collection and transfer stations, the authorization of all off-site hazardous waste handling facilities, and the establishment of a strong data base for ambient environmental conditions at and surrounding the facility site all come under the Corporation's purview.

WASTE COLLECTION AND TRANSFER

Construction of a hazardous waste treatment plant is, in itself, a major achievement. However, in order to move waste materials efficiently through the province, a system of local waste collection facilities and regional transfer stations is being planned. Wastes will be delivered directly to these sites by the generator. At the transfer station, wastes will be sorted and bulked where possible, then transported directly to the treatment plant at Swan Hills. Such a system will facilitate waste management at the regional level, and will provide for the regulation and monitoring of hazardous waste movement.

SUMMARY

The development of Alberta's Special Waste Management Program is now underway. For the first time in North America, an integrated treatment plant has been sited based on environmental and social acceptance. The treatment plant will be fully operational in 1987, with a network of collection and transfer stations planned province-wide. The system is overseen by a Crown Corporation, the facilities are being built by the private sector, and the operations within the system are regulated by government agencies.

TRICIL'S SARNIA APPLICATION
PUBLIC PARTICIPATION
AN EXERCISE IN FRUSTRATION - OR WAS IT?

Robert J. Redhead
Tricil Limited

Public Participation = Communication

In the field of hazardous waste management, the operation of treatment and disposal facilities can be successfully undertaken only with the acceptance and preferably with the approval of the neighbouring community.

We all know about N.I.M.B.Y. and have all seen media coverage of outraged citizens concerned that their rights, if not their lives, are being threatened by a proponents project.

In the past, industry's reaction to such events was often to brand the complainers "loud-mouthed agitators" and to display a similar level of outrage that their activities could be questioned by such "idiots".

Such is the stuff of media confrontation which sells newspapers, attracts viewing audiences and makes or breaks politicians.

Is it possible to avoid confrontation and still come to a mutually acceptable conclusion? Sometimes it can be done; - through mediation, through representation to a tribunal or through a public hearing. These processes all involve compromise rather than confrontation and communication rather than confusion.

The first and most important step is communication and often new or different channels of communication must be developed. This is a complex and continuous process requiring much attention to detail and continuous nurturing and vigilance. It is also a two way street.

Such communication with the public is foreign to many industries, not just the waste management industry. Organizations will communicate with employees through meetings, newsletters and notices; they will "communicate" with customers through advertising sales personnel and promotion, but they seldom talk to the public. Many times they don't know what to say or how to say it.

Let's look at our industry. 95% of all information the public receives about the waste management industry is bad news. Most of it occurs during a crisis or the latest environmental scare, and all of it is transmitted through the media.

We and all industry must be able to talk to our publics directly, honestly and consistently. How do we do this? There are many ways:

One-on-One
Neighbourhood Visits
Plant Visits
Group Tours
Public Meetings
Speaking Engagements
Media Contacts
Press Releases
News Conferences
Direct Mail
Newsletters

Recently Tricil made application to extend our secure landfill operation at Sarnia - the first major hazardous waste landfill application in Canada for many years. We know from day one the proposal would necessitate a public hearing, and the way in which we prepared included using and/or developing all of the communications channels outlined above.

Fortunately many of these channels were already in existance, developed over the years, initially by reactive communications and more lately by pro-active communications. Pro-active public communications means making the initial contact with the public or media and passing along your message. This way you can inject some good news, although remember, you still have to communicate the bad news, warts and all.

In the Sarnia Landfill Extension Application, the message we wanted to "communicate" was:

1. That there would be a full legal hearing process, with full disclosure and no short cuts.
2. That the technical investigation had been complete and detailed and the proposal was environmentally sound.
3. That we wanted to have public input and involvement.

If we succeeded in doing this, the public would understand the hearing process and would understand the technicalities of the proposal. We would also have time to modify our proposal to accommodate or incorporate local concerns.

Communications were aimed at various audience groups, and we wanted as many groups as possible to be at worst neutral or at least supportive of our project.

Our audience for this communications program consisted of many different groups so our methods varied depending on the group, as did our expectations.

AUDIENCE	EXPECTED BEHAVIOUR
Local Opposition	No Change
Employees	Support
Neighbourhood	Less Volatile
Customers	Neutrality
Politicians	More Supportive
Crown Corporations	Supportive
Media	No Change
Regulators	Better Understanding of Public Participation
Environment Lobbies	Neutrality

Some of the tools used were:
Newsletter - "Common Ground"
Personal Visits - "Driving and Talking"
Technical Applications
Summary Documents - "A Most Suitable Site"
Media/Employee Briefings
Public Workshops
"New Issue" Documents

We developed a comprehensive set of application documents and made sure that copies were available to all interested groups including employees well in advance of the Hearing. We prepared several summaries in various lengths and detail and we created many visual aids for use at news conferences, public workshops and at the Hearing itself.

We published a newsletter, "Common Ground", which contained information about waste management, environmental protection, Tricil and the Landfill Extension Application.

We met with representatives of all the audience groups to explain and answer questions on the proposal.

We held a series of public workshops in the local community including , evenings and weekends, to discuss the application and receive comment and criticism from our neighbours. We had the Plant open for inspection by anyone who wanted to visit and we talked to local service groups, teachers, school children, naturalist groups and politicians.

Throughout the entire exercise we kept the media well informed with phone calls, news conferences, news releases and one-on-one interviews.

So how did it all work? What did we achieve?

Well, for a start, those of us directly involved knew the application intimately and we were well prepared to discuss all aspects under cross examination at the Hearing. We discovered several local areas of concern and we were able to modify the proposal to address those. Most important of all we had all interested parties discussing our proposal using our words. A major concern to the proponent in a Hearing of this type is the stall tactic of a request by an intervener for an adjournment on the basis of insufficient time to prepare or incomplete information. No such adjournment was requested at our Hearing - all information had been available made available.

What effect did our efforts have on the audiences?

	BEHAVIOUR	
AUDIENCE	EXPECTED	ACTUAL
Local Opposition	No Change	X
Employees	Support	X
Neighbourhood	Less Volatile	X
Customers	Neutrality	Support +
Politicians	More Supportive	X
Crown Corporations	Support	Not Achieved
Media	No Change	Support +
Regulators	Better Understanding of Public Participation	Not Achieved
Environment Lobbies	Neutrality to Company	Partially Achieved

Since several years before the Hearing we had been conducting annual public attitude surveys in the local community and in the Province at large which allowed us to verify our subjective evaluation of the communications activities.

In the case of O.W.M.C., the Crown Corporation, the process forced them to come out of the closet, to commit themselves and take a position relative to Tricil.

What lessons did we learn during the process?:

- Be Transparent
- Proposals and Research must be of the Highest Quality
- Answer Criticism with Fact, not Emotion
- Assume Nothing
- Understand Lobbies
- Play by the Rules of the Process
- Keep the Faith - Have Patience!

The Public Hearing Panel ruled in favour of Tricil's proposal, however a local opposition group appealed the decision and that appeal at the time of this writing was in the hands of Cabinet therefore many inferences and conclusions cannot yet be drawn.

We started work on this project in August 1982 and took all possible steps to expedite the process. Now almost 4 years later we await a decision. In terms of environmental hearings this was fast - some have taken 9 or 10 years to reach a decision.

Effective regulatory and public relations management is important to an industries achievement of goals. Organizations therefore must learn to work with the challenges and opportunities provided not simply avoid its pitfalls.

Within Tricil, as you have seen, we have developed and used many of the tools. We must learn to choose carefully from this array those which are necessary and cost effective for each specific project.

Was the Sarnia Project an exercise in frustration? Certainly not - it was a glimpse of the shape of things to come.

A GUIDE TO PUBLIC CONSULTATION/ ENVIRONMENTAL MEDIATION OR "WHAT'S IN A BLEND"

John R. Willms
Environmental and Land Use
Planning Lawyer

and

G.D. Willson
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Underwood McClellan Assoc.

1. SCENARIO

You are all familiar with the rituals of public consultation in 1986. Let us propose one scenario which I am sure all of you will recognize.

At the stage at which proponents are starting detailed design of the proposed waste disposal operation at site 'a', opponents say that there is a better site ('b') in the opposite end of the municipality. Proponent observes that it is in a zone identified at an earlier stage of the site selection process as being hydrogeolically inferior, and realizes that consideration of site 'b' will create a new and equally dedicated and vociferous band of opponents from that area.

The opponents have created a serious dilemma for proponent; and a win-win situation for themselves. If proponent spends the extra money and time, and the alternate site turns out to be unacceptable, opponent says "process is phony and rigged, and this proves it.....proponent can't say that it studied alternative in good faith, because it is already committed to site 'a', and is prejudiced against site 'b'". If proponent refused, having anticipated the technical and procedural futility of devoting further and unbudgeted resources to studying the alternative site, it will be accused of insincere and inadequate public consultation, charges which have a tendency to stick, particularly in the political arena.

Is this scenario to be played out with variations until the pendulum swings back against public consultation? If the efforts of the participants at this conference are any indication, we can learn from such scenarios and avoid them in the future. We have some suggestions and appreciate the opportunity to share them with you today.

2. PUBLIC INVOLVEMENT AND POWER SHARING

Effective public involvement requires a degree of power sharing by the parties. Proponents must learn how to share some decision-making and intervenors, in turn, will be required to abandon their ability to stultify through entrenchment and ambuscade.

Sharing of decision-making is understandably perceived by most proponents (and their lawyers) as being an unlawful and unacceptable abdication of authority and responsibility. The persons involved, usually municipal councillors or

members of a board of directors, are answerable to a constituency which is entitled to hold them, and no other parties, responsible for conformity to budget and success of the mission. Proponent's representatives, not intervenors, will face the longer term consequences of final decisions. The statutory mandate authorizes proponent and nobody else to decide and act.

The problem of power sharing is exacerbated by the trend to large regional and in some cases such as Ontario Waste Management, provincial waste disposal facilities. Those interested in or directly affected are usually a small minority within the overall constituency of the proponent.

Nonetheless, conventional wisdom and practice dictate that comprehensive public involvement is essential to success for proponents. Reliance on the adversarial system for timely authorization of any given undertaking is risky, costly and often futile.

3. THE USE OF PUBLIC INVOLVEMENT

To encourage effective public involvement and solve the issue of shared decision making, it is imperative that the planning process be structured and implemented properly from the outset.

We contend that the most viable process is a blending of what is currently referred to as community relations, public consultation and environmental mediation. What community relations has to offer is the establishment and maintenance of a general awareness in the community about the waste management issue. This it does through various printed messages and information displays; it is primarily information out.

Public consultation through its various mechanisms assists in the generation and procurement of advice from the community. The advice does or does not have to be needed by those ultimately responsible for the project. The community, however, is owed an explanation of what is to be done with its advice.

Environmental mediation establishes agreement between a proponent and the interested community parties about how a waste facility is to be developed and operated. There are joint commitments made by all parties involved which are respected by the community as a whole. Mediation is also used to develop a process whereby communications between the proponent and the interested parties are enhanced.

4. A SEVEN PART BLEND

The blending of these three approaches to public involvement and shared decision making takes place through seven steps. To be sure, the use of each approach varies at each step. It is important to note as well, that what we are offering here are guidelines to better decision making, not ways of eroding propontent's or regulator's responsibilities.

4.1 Definition of Problem/Issue

The beginning of any waste management or facility siting process requires the proponent to define the problem or issue. This definition can also form the basis for community involvement; the community should be invited to react or respond to the problem/issue as initially defined.

To do so, the proponent must cause affected, representative community interests to solicit their perceptions of the problem/issue. In doing so, it will be able to

- check and modify his definition for completeness;
- indicate to the community that he expects its input to resolving this problem/issue; and
- encourage the community to start subscribing to the problem/issue.

4.2 Identification of Interests to be Involved

Once the initial definition of the problem/issue has been placed in the arena of community values, it is important to determine which community interests are to be represented. They certainly include people residing or working within or close to the study area and those with solid, environmental and economic interests.

It is imperative that all parties involved understand the basis for the involvement of each. In an unobtrusive and diplomatic manner, this helps legitimize the stakeholders in the planning process.

4.3 Parameters of the Process

The definition of interests helps all parties involved; it is not just a means by which a proponent can manipulate community interests. It stimulates an awareness for the context in which the concerns of each party arise.

In developing the parameters of the task at hand, the proponent has to be forthright with its assignment, whether it is governed by local government or a board of directors. As in step 1, definition of the problem, its thinking should not be restricted. A sharing of perceptions about the problem/issue among the interests involved must be encouraged. This sharing of perceptions should also include an acknowledgement among the parties about their legal requirements and opportunities. This will keep in delineating how the problem/issue is to be addressed and in what detail at what point in the planning process.

An appreciation among the parties for their perceptions of the problem/issue plus an awareness of formally imposed decision making processes, encourages the parties to deal with one another on a more equal basis. Aware of why each is involved and what their legal rights are, potentially threatening situations are alleviated. People understand what is happening and why and what they can do to influence the process.

4.4 Development of Alternatives

A sense of shared power can be further articulated through the development of alternatives to solving the problem/issue at hand. Each party should be encouraged to offer suggestions.

Although it is imperative for each party to be honest about what it feels are viable solutions, there should be an agreement to consider anything with possibility. This is especially true of the proponent. If it is going to maintain the trust of the interested community parties and have them subscribe to the process and its resulting actions, their suggestions have to be reviewed with sincerity and respect.

4.5 Assess Alternatives

The need to show respect for the various inputs is crucial in assessing the alternative ways in which the community waste problem/issue can be addressed. The various parties have to be actively involved in reviewing and evaluating options. This review and evaluation must include discussion of the reasons why a particular alternative will work and why another will not. In developing such a comparative evaluation, the various parties involved will have a more thorough understanding of the most viable solution. To the extent that as they are involved in developing it, the parties will feel some responsibility for its implementation.

4.6 Refinement of Alternatives

This sense of responsibility will carry over into the refinement of preferred alternatives. The various parties will be more willing to consider modifications to their initial suggestions once they have agreement on some basic constraints and exclusions. They should be willing to act in concert to ensure their basic demands as a group are met.

In refining the alternatives and developing the ultimate recommendations, it is imperative that every party represented be given some responsibility in subsequently enacting the solution. Not only do parties have to be involved with the development of a workable solution, they have to be seen as being active in its application. This further binds the parties to the solution, and maintains their credibility in the eyes of their respective constituents and the community as a whole.

4.7 Recommendation

In offering the recommended solution, it is imperative that every party's continued responsibility be acknowledged. This cements the sense of community partnership with the proponent. It also eases any community anxiety about how the solution is to work once implemented and how future problems might be addressed.

5. WHO DOES THE BLENDING

What kind of individual or individuals should be involved in orchestrating this? In today's jargon he may be referred to as an environmental mediator; one who is:

- neutral, and so perceived by the parties;
- accepted by the parties;
- able to operate in the context of an agreement between the parties.

In other ways, we are considering more of an arbitrator; one who:

- will have the duty to make recommendations, and the duty to comment publicly and formally on the behaviour of any party, should such fail to abide by his recommendations;
- may well be given the authority to make rulings on incidents of the relationship between the parties.

Finally, we are also condidering a public participation coordinator, inasmuch as limits cannot be placed on the period of his involvement, as often are on the retainer of a mediator or arbitrator. The best single work to describe this individual is referee.

The referee may not "last the night". During a long term involvement, he may lose his perceived neutrality, especially if a series of rulings are made which consistently offend one of the parties. In the latter stages of planning and application for approvals, a more conventional mediation process may be invoked. It is unlikely that our referee can play this role.

Notwithstanding the risks, the potential benefits to the waste management decisionmakeing process of the removal of some of the psychological and constitutional objections to power sharing are obvious and significant. We believe that the application of our suggested approach as outlined will help.

VIEW FROM THE TRENCHES

Margherita Howe

Chairman, Operation Clean Niagara

Paper unavailable at time of printing

PROTECTING MARINE ENVIRONMENTAL QUALITY FROM LAND-BASED POLLUTANTS - THE ROLE OF FRAMEWORKS, STRATEGIES AND MARINE ECOTOXICOLOGY

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ABSTRACT

Marine waters receive many wastes from point and non-point sources. Land-based pollutants are of particular concern to the continued uses and "ecosystem health" of estuaries and nearshore waters. A recent UNEP Guideline (Montreal Guidelines, April 1985) presents an environmental protection framework that links uses of specific environments and the choice of control strategies, with scientific understanding of the fate and effects of pollutants i.e. ecotoxicology. At the same time, an "environmental sensing" strategy was developed within Environment Canada. It identifies the key scientific and decision-making activities required to assess and control toxic substances being discharged into various environments, particularly aquatic. This paper describes in particular the role of the Montreal Guidelines and the Environmental Sensing Strategy in a Canadian initiative to focus on cooperative strategies for the protection of Canadian marine environments. The contribution of biological approaches in problem identification, assessment, control and monitoring is described, using specific examples. Applied ecotoxicology is essential for choosing the most effective disposal options for wastes designated for marine waters. Understanding the current marine frameworks and strategies for choosing effective control and monitoring procedures, and the essential contribution of marine ecotoxicology, should lead to adequate controls of pollutants from land-based sources.

INTRODUCTION

Estuarine and coastal waters receive large quantities of man-made wastes from point and non-point sources from the land. Such wastes and their component chemicals contaminate these waters, often act as pollutants (i.e. causing adverse effects to human health or biota), and are a continuing and growing threat to the legitimate uses and "ecosystem health' of our coastal waters (Duedall et al. 1983). In other words, land-based pollutants are a growing threat to marine environmental quality.

Marine environmental quality is the condition of a marine environment (shoreline, estuary, bay, harbour, nearshore and offshore waters, etc.) measured relative to each intended use of that environment. It is usually assessed quantitatively, on temporal and spatial scales, and is measured relative to objectives and limits set by environmental, health and resource agencies. It may include subjective perceptions of degree of acceptability. Its measurement requires having sensitive and interpretable indices of condition and change, and established limits and objectives for emissions and receiving environments, respectively.

The importance of maintaining a high level of environmental quality in our estuarine and coastal waters cannot be overstated. Canada has a 243,797 km coastline and an exclusive economic zone of 4.7 million square km. It sustains major fisheries, industries, the traditional life style of maritime and native communities, tourism and recreation, transportation, and diverse biota, habitats and ecosystems. The economic value of Canada's marine waters is in the billions of dollars, while other values (social, cultural, ecological and intrinsic) are inestimatable.

Canada's marine waters are increasingly exposed to a wide variety of physical and chemical stresses, coming from land-based, transportation, resource exploitation and waste-dumping origins. The highest concentrations of anthropogenic compounds are generally found near riverine, industrial and municipal discharges (i.e. land-based). There are many examples in Canada, on all three coasts, where levels of contamination are high, pollution is occurring or is likely, and long-term implications to fisheries and human health are uncertain. Examples range from Sydney, N.S. to the Fraser River estuary on the B.C. coast.

At the present time sources are under some level of control, (e.g. refinery wastes, fish processing plant wastes) or are continuing unabated (agricultural land runoff, sewage from major cities). The range of inputs and their volumes is large. Control options range from industry-wide end of pipe control to site specific emission controls based on a knowledge of what particular environments can tolerate and assimilate.

Control options for contaminants and pollutants entering marine environments have to be chosen as a balance of intended use, available technologies for treatment, knowledge of the fate and effects of the offending parameters, cost, and probably other factors. A number of managerial frameworks and strategies exist to assist in this choice. We would argue that these frameworks and strategies must be science-based, though their selection must take other factors into account. Fate and effects studies are, therefore, critical to our understanding of the environmental or assimilative capacities of a particular marine ecosystem.

FRAMEWORKS

We are not advocating a new beginning or a radically different approach. The management of residuals discharged or dumped into the marine environment has been discussed for decades. The international community began with an emphasis on oil and other wastes from ships. Within a matter of years, attention turned to ocean dumping of wastes generated on land, deep sea radioactive waste disposal and other problems, all instrumental in leading to major conferences which culminated in the Law of the Sea.

In the 1960's and early 1970's, several countries in regional clusters recognized that point and non-point land-based sources were contributing substantial quantities of contaminants to the marine environment. As such, a number of conventions and protocols were enacted including the Paris Convention for the Prevention of Marine Pollution from Land-Based Sources and the Quito Protocol for the Protection of the Marine Environment and Coastal Area of the Southeast Pacific (Hirvonen and Côté 1986).

These pieces of the global mosiac had not yet been drawn together into a comprehensive global approach " to prevent, reduce and control pollution of the marine environment from land-based sources, including the effects of such pollution on coastal areas and to minimize the adverse effects that have already occurred". This approach recognizes that there are many activities competing to derive benefits from the ocean. All uses of the environment by man impart certain stewardship obligations on individuals, industries and governments. As such, it is incumbent on us to consider all alternatives before decisions are made. In some instances, marine disposal of certain contaminants may be the more environmentally acceptable alternative when compared to landfilling, incineration, storage or inaction. The goal is protect marine ecosystems and ensure their sustainable use, by maintaining their quality within acceptable limits determined by scientific, institutional, social and economic factors. This paper makes the case that an acceptable level of marine environmental quality will only be achieved and maintained when hazardous and other waste management occurs within a broader framework. A brief description follows of some recent efforts on global, national and subnational frameworks and strategies.

The Intergovernmental Oceanographic Commission published The Comprehensive Plan for the Global Investigation of Pollution in the Marine Environment (GIPME) in 1976 (UNESCO 1984) (see

Fig. 1). This plan has four stages: mass-balance, contamination assessment, pollution assessment, and regulatory action. Authors of the plan state that "it exemplifies a logical and intrinsically scientific approach to the problem of assessing and regulating marine pollution", on both a regional and global scale. The plan is organized strategically, so as to progress logically and in priority from methods to training to the conduct of surveys and specific measurements. GIPME, however, focussed primarily on quantifying the state of the marine environment. As such, its scope was more limited than the frameworks that follow.

Côté and Brown (1985) describe Part XII in the 1982 UNCLOS (United Nations Convention on the Law of the Sea), which provides a framework for the "protection and preservation of the marine environment". According to Côté and Brown, the Convention stated that "there are obligations to prevent, reduce and control pollution of the marine environment from any source; to cooperate in the promotion of studies and exchange of data related to marine pollution problems; to monitor risks and effects of marine pollution; to assess the potential effects of projected activities; and to enact laws to deal with pollution from land-based sources, seabed activities, vessels and the atmosphere". In addition to providing a framework, the Law of the Sea also places obligations on the signatories of the Convention.

The International Union for the Conservation of Nature and Natural Resources, with the support of various countries, has developed the World Conservation Strategy (Pollard and McKechnie 1986). The WCS can be viewed as a third global framework. The Strategy has three objectives which together "form a framework for priority requirements which are to be considered by each nation: to maintain essential ecological processes and life-support systems, to preserve genetic diversity, and to ensure the sustainable utilization of species or ecosystems". The Canadian government has recently endorsed this strategy and framework, calling in particular "for a federal-provincial effort to develop conservation strategies for coastal zones and offshore areas" (Côté and Brown 1985).

The comprehensive approach mentioned above has now been enshrined in UNEP's Montreal Guidelines for the Protection of the Marine Environment Against Pollution from Land-Based Sources (UNEP 1985, Hirvonen and Côté 1986) The guidelines are to assist governments in the process of developing appropriate bilateral, regional and multilateral agreements and national legislation for the protection of the marine environment against pollution from land-based sources. The guidelines were developed by a UNEP Working Group of Experts and represent the first attempt by the international community to address this subject at the global level. The guidelines cover areas such as: cooperation to establish rules, criteria, standards and recommended practices and procedures to prevent, reduce and control pollution; scientific and technical cooperation; establishment of programmes for monitoring and data management; establishment of specially protected areas; and development of control and prevention strategies. In addition, a number of environmental protection principles are discussed within the context of an environmental protection framework (Fig. 2). The guidelines provide three major annexes: (1) control strategies and instruments for achieving environment protection; (2) the selection and classification of substances to control; and (3) the design and implementation of monitoring, and the quality control and management of data. Control strategies are based on marine environmental quality standards, emission standards, and environmental planning, respectively.

At the national level in Canada, an Environmental Sensing Strategic Framework has evolved in the past two years in Environment Canada's Toxic Chemicals Management Program (Wells and Eisenhauer 1984, Eisenhauer pers. comm.). Environmental sensing is defined as the scientific and technical activity of detecting and defining the pathways, fate and effects of toxic chemicals (i.e. anthropogenic compounds) present in, or entering, natural environments. The framework (Fig. 3) organizes a program according to its primary objective, its products and the activities which achieve the objective. The three products of environmental sensing are that (1) decision makers are equipped with the best available environmental knowledge for decisions; (2) the outcome of interventions are provided to the decision makers; and (3) potential environmental problems are identified for the decision makers. The resulting framework ensures that the applied science on the fate and effects of chemicals is closely linked to all

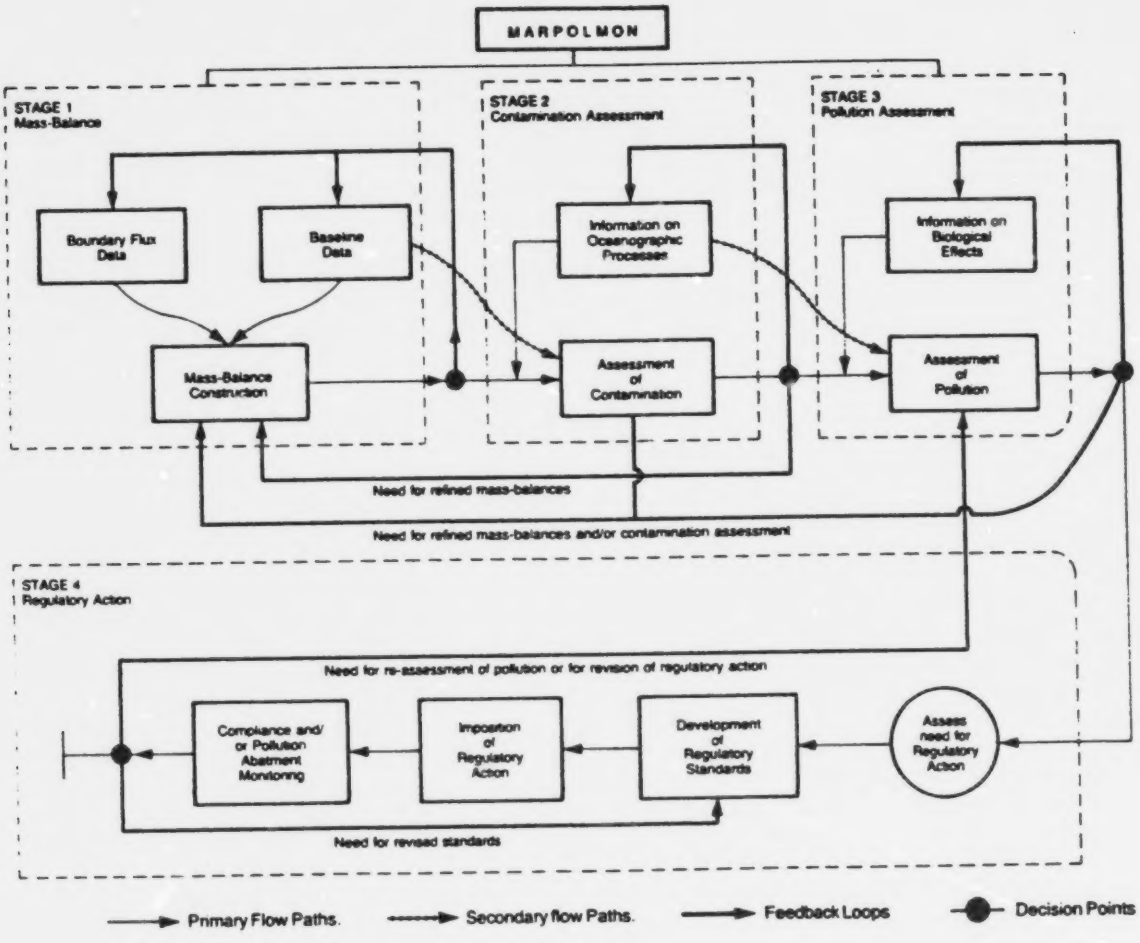

Figure 1. Components and Logic of the GIPME Comprehensive Plan

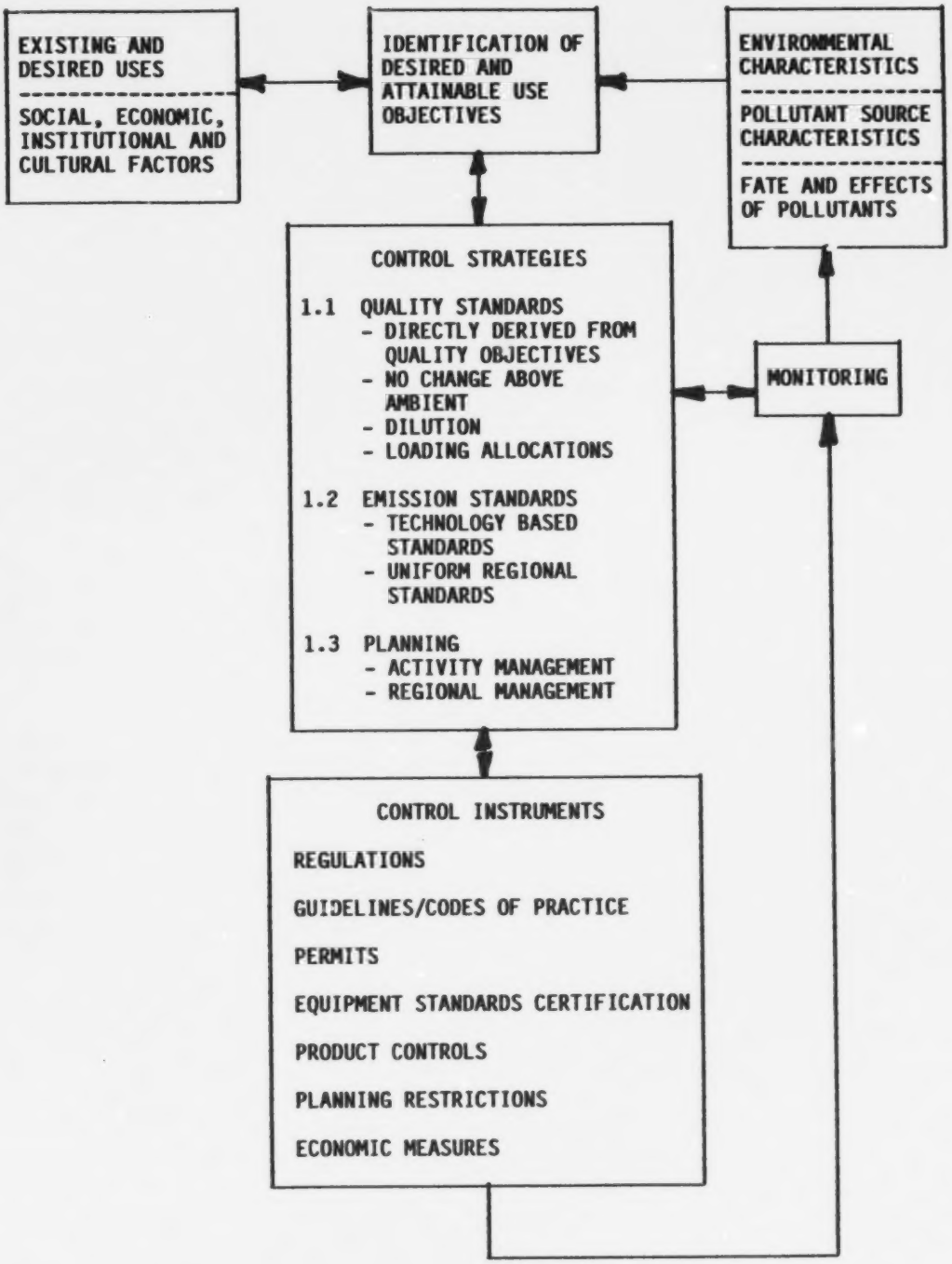

Figure 2. The components of a comprehensive environmental protection framework for the control of marine pollution from land-based sources (UNEP 1985).

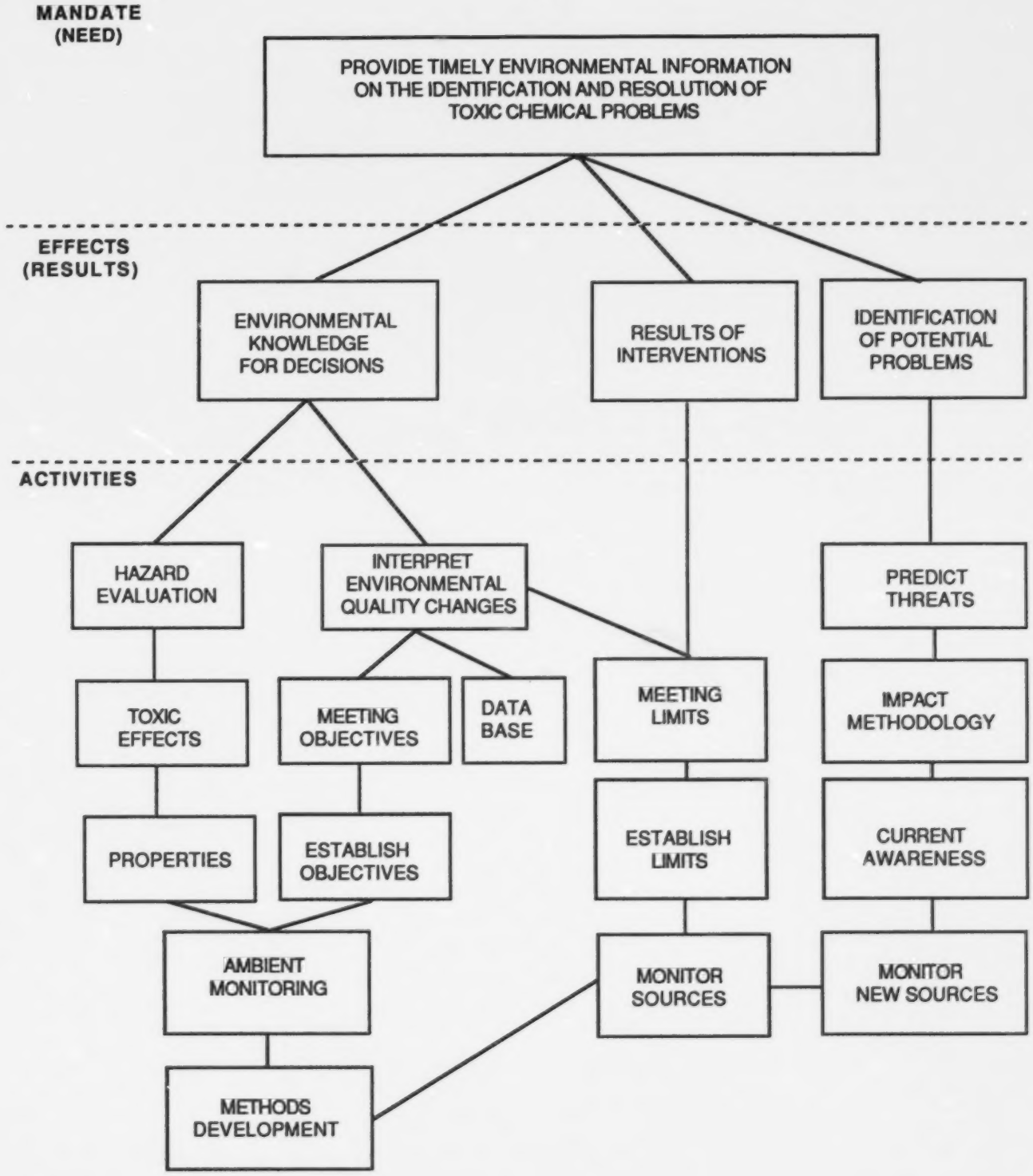

Figure 3. Environment Canada's Toxic Chemical Management Program - Results Definition Model For Environmental Sensing (developed by Environment Canada in 1985).

control activities, and to the prediction and recognition of new problems i.e. it ties the science of ecotoxicology to interventions, and to a "watchdog" or "early warning" role, both essential to the effective control and prevention of serious environmental problems.

At the subnational level, which could be either regional or provincial, few frameworks have been developed. The Great Lakes Water Quality Program is perhaps the best known example. Others that relate directly to marine pollution from land based sources include the Fraser River Estuary Study (discussed below) and the St. Lawrence River Action Plan (Environment Canada, 1984, revised 1986). In 1975, a proposal was made by Johnston et al. for a Maritimes Coastal Zone Commission (Johnston et al. 1975). The objective was improved coordination of governmental planning and regulatory activities as they pertain to the coastal zone of the Maritime Provinces. The report was never given serious consideration at the time.

Other frameworks for unique marine environments may or may not be necessary. Because of institutional and legislative problems, Côté and Brown (1985) suggested "a decision-making framework with systemic capabilities matching the range and intensity of issues now involved in the marine environment". A policy framework, covering ethics, environmental and developmental objectives, basic knowledge of marine ecosystems, protection of selected areas, and regulations and information dissemination is suggested. Such a framework would consider the control of land-based pollutants.

The main point is that various frameworks and strategies exist at global, national and regional levels to be used to priorize problems, select control or intervention techniques, and monitor their success, within Canadian jurisdictional and institutional boundaries.

REGIONAL PLANNING AND ENVIRONMENTAL PROTECTION STRATEGIES

The current approach to marine environmental protection in Canada is usually to focus on a specific project or industry. The regional ramifications resulting from incremental additions of similar or ancillary projects that could result in cumulative impacts in estuarine or coastal regions are generally not addressed, let alone predicted. As such, the potential long term social, economic, and environmental effects likely to occur in a given area with multiple developments are not fully incorporated into the planning processes by different levels of government. Contamination of water in shellfish growing areas from agricultural, municipal and industrial wastes is a case in point. Meaningful progress in resolving conflicts in coastal environments caused by land-based sources of pollution will only be made when a broader approach is implemented.

Regional strategies for environmental protection must integrate socio-economic and ecological factors into the decision-making process for industrial, urban and rural development. The following strategies modified from UNEP (1985) can be used for the protection and management of estuarine and coastal environments:

Activity management

Some activities planned in an area can reduce the value or use of a particular environment. Consideration should be given to whether the activity is essential, and if so, whether it can be accommodated elsewhere or in a different manner e.g. Lancaster Sound.

Use designation

Use of the receiving environment is the determining factor for pollution control standards and provides the basis for applying regulations or guidelines on proposed developments. This application may result from a

perceived threat to an established economic base or cultural value, or a conscious effort to change the existing use of a receiving environment.

Coastal zone management

"This strategy employs planning capabilities to ensure that social, economic, and environmental goals are satisfied to the maximum extent possible. In support of this, potential activities are assessed as components of a coastal zone. Planning is based on regional socio-economic and ecological considerations. Zoning and other land-use restrictions or modifications are major regulatory tools. Many States employ the use of regional planning authorities or councils, given the task to manage overall resource planning within a particular coastal area." (UNEP 1985) e.g. Chesapeake Bay.

Watershed or drainage basin planning

"This strategy acknowledges that most contaminants (a large proportion of pollution) enter the marine environment via watercourses. It does not necessarily account for inputs via the atmosphere, although air management areas have also been employed for control purposes. Through consideration of socio-economic and environmental factors utilizing a drainage system as the boundary limit, the desired uses and level of quality that can be attained for any given marine water body are determined. Pollution via watercourses is controlled through regulation of point and diffuse sources of such pollution within the given watershed." (UNEP 1985) e.g Fraser River Estuary.

Coastal conservation strategy

A conservation strategy would require a change in development philosophy and as such takes on a much longer term perspective. Its focus is the promotion of a sustainable balance between natural resources and a modest standard of living and an improved management of species, populations and critical coastal habitats (IUCN 1985). Its implementation requires a better means of assessing the value of resources and impacts, and an emphasis on causes rather than symptoms, as well as prevention rather than cure.

CHOICE OF CONTROL OPTIONS

Having established a planning system that encourages strategic and project-specific environmental impact assessments, we can now look at the range of control options that are available to the environmental management or regulatory agency. It is accepted that policy decisions by governments preclude the use of some options. We would urge that they should not be dismissed out-of-hand as there are strengths and weaknesses in each case.

As described in UNEP (1985), the options are marine quality-based strategies, emission control-based strategies, and planning-based strategies. Of note here is the range of control instruments that have been used in the various jurisdictions:

i) Regulations
ii) Guidelines/Codes of good practice
iii) Permits
iv) Equipment standards certification
v) Product controls
vi) Land use restrictions
vii) Effluent fees
viii) Tax policies

In many situations, a combination of these control instruments is necessary to put the most effective control in place. Several factors play a role in the choice of strategies and instruments. Economic factors include the economic viability of various sectors, availability of public financing, and the polluter pays principle. Social and political factors such as the existence of infrastructure, the existing land uses potential uses of the marine environment and the social-cultural awareness of the population are also important. Finally, there are a number of scientific and technical factors from the science of ecotoxicology which play a role in the decision-making. These are:

i) availability of data on physical and chemical characteristics of the receiving environment
ii) availability of expertise
iii) analytical capability
iv) monitoring capability
v) knowledge of the sensitivity of ecosystems to contaminants

CASE STUDIES

This section describes a few marine localities in Canada which require comprehensive approaches to pollution assessment and control. Pollution management in these areas is dependent in part upon our current and future capabilities in marine ecotoxicology.

Halifax Harbour

Halifax Harbour receives many types of wastes. The primary type is untreated municipal wastewaters (i.e. domestic waste) from most of the surrounding municipalities, and about which there is legitimate concern. From recent studies, there is considerable evidence of reduced water quality (elevated fecal coliforms and high BOD loadings - ASA (1986)) caused by such wastewaters. The potential exists for serious long-term impairment of some traditional uses of the harbour and surrounding waters (swimming, boating, fishing, aesthetic enjoyment, etc.).

Some industries, such as the refineries, have treatment facilities for their wastewaters. Most do not and they discharge through the various sewer systems or directly into the harbour. Hence, as in any industrialized harbour, there are many waste inputs, all but the non-point ones (i.e. run-off, toxic rain) being amenable to treatment.

A study of Halifax Inlet water quality is underway, in three phases (ASA 1986). The final product will be a numerical water quality model which allows simulation of processes affecting the fate of sewage effluents in these waters, and predicting the impact of the effluents on water quality. The model will be useful if applied within the context of water use classifications (ASA 1986). The model, although limited to conventional water quality parameters and excluding toxic substances and any measures of biological effect, fits into the environmental protection framework of the Montreal Guidelines (Fig. 2).

Management of the water quality in Halifax Harbour has received much attention in recent years (K. Hamilton, pers. comm.). It will benefit from continued analysis as per the modeling study, particularly based upon the principles and concepts in the Montreal Guidelines (UNEP 1985).

Sydney Harbour, N.S.

Contamination of this harbour is an example of a point source but of a different nature than is traditionally considered under this category. The South Arm and some portions of the main harbour receive wastes from a tidal "tar pond". The "pond" has been created by the deposit of more than 80 years of tarry material at the mouth of Muggah's Creek. The Creek receives effluents and runoff from the Sydney

Steel Corporation's coke ovens and its predecessor, the Dominion Steel and Coal Company. The waste site contains approximately 500,000 tonnes of material.

Since the tar pond is washed by the tides twice a day, a large quantity of polynuclear aromatic hydrocarbons (PAH) and other chemicals flow into the waters of South Arm. They have also found their way into sediments resulting in some of the highest concentrations measured anywhere (Matheson et al. 1983). One direct consequence has been the contamination of lobsters. Concentrations of certain PAHs in lobsters has reached levels viewed by health officials as presenting unacceptable risks to the consumers. The fishery in a portion of the harbour is closed.

Without remedial action, this pollution would continue to occur for an indefinite period. Studies costing $400,000 of possible control measures have been undertaken. Agreement has been reached to remove the tarry materials and burn them as fuel at SYSCO. In so doing, the costs of the controls will be recovered.

There are other point and non-point sources which contribute PAH's to Sydney Harbour but none of these are as significant as the effluent from the coke ovens and the 'tar pond'. Once clean-up of the 'tar pond' is completed, precautionary measures will have to be taken to ensure that other sources will not contaminate the harbour.

Caraquet Bay, N.B.

Primary sources of pollutants to Caraquet Bay are from municipal and agricultural activities resulting in point and non-point discharges to coastal waters. This Bay is the breeding ground for the northernmost population of the American oyster, Crassostrea virginica and is potentially a very productive area. Some estimates of the oyster fishery have exceeded 1.5 million dollars. In addition, the Bay supports a clam fishery. Approximately 600 people are directly involved in clam and oyster fisheries.

Land-based sources of pollution are direct discharges of untreated sewage, storm sewers, urban runoff, discharges from feedlot operations e.g. piggeries and pasture land runoff. In addition to wastes which contribute fecal coliform bacteria, there are other sources of contamination. Industrial wastes from fish plants and small secondary industries, discharges from ships, runoff from peat mining operations, pesticides in runoff and airborne drift also add to the total loadings of pollutants.

Sewage and other discharges containing fecal coliform have presented the greater threat to the fisheries. A stringent standard set under the Canada-U.S. Bilateral Agreement on Shellfish has not been met. A standard of 14 FC/100 ml, one of the few marine water quality standards in Canada, has been set to protect the health of consumers. Consequently, large areas of the Bay are closed temporarily or permanently to the direct harvesting of shellfish.

Resolution of the problem will require controls on existing sources of contamination by the provincial and federal governments, by-laws at the municipal level requiring connection to sanitary sewers and restricting connection of roof drains to the same sewers, incentives to farmers to implement environmentally acceptable agricultural practices and last but not least, better planning procedures to prevent future pollution.

Saint John Harbour, New Brunswick

Local fishermen and others considered that the considerable dredging required to maintain the harbour and channel at Saint John was having a detrimental impact on the fishery in the area and was impacting the marine fauna and flora along the coastline. A workshop brought together concerned parties,

both causative and affected, in 1981 at the Saint John campus of the University of New Brunswick. At this workshop, the results of considerable analysis of sediment distribution and dredging-related activity, sponsored by the Ocean Dumping Research Fund, were tabled which indicated that dredging per se was not the major, or perhaps even a significant, source of pollution. Natural processes accelerated by onshore development and growth of Saint John related to the pulp and paper, fishing and other industries were generally indicated as more likely sources of environmental degradation or change. The use of the harbour for sewage disposal and modifications resulting from causeway and wharf construction were also seen as instrumental in introducing contaminants and in changing the flow pattern and flushing action of the harbour.

Continued development of the Port and surroundings is likely to result in a further decrease in environmental quality. It was, therefore, the consensus of the workshop that some broader consultative or regulatory authority would be required to advise upon or control the use of the marine environment in and around Saint John to minimize further impact and even to redress more of the environmental degradation which has occurred. In addition, a need for a physical model of the Saint John Harbour and environs was proposed, as was the development of a master environmental plan to complement the existing Decade of the 80's Development Plan for Saint John. A long-term monitoring program was also envisaged

Fraser River Estuary

The problem in the Fraser River Estuary is one of contaminants and pathogens from four major sources: municipal effluents, storm water, direct industrial discharges and landfill leachates. Collectively, these discharges have affected water quality in parts of the estuary, closed shellfish harvesting areas, closed beaches for public swimming, contaminated sediments, invertebrates and fish, and degraded and caused eutrophication on a nearby bank.

There are five estuarine management programs in place or in the process of development in southern B.C.; The Fraser River Estuary Management Program (FREMP) is the major one (L. Hildebrand, pers. comm.).

The FREMP started due to the realization that there needed to be "a means for accommodating a growing population and economy while maintaining the quality and productivity of the Fraser River's natural environment" and "a strong commitment among key agencies to work together to achieve common goals and objectives concerning management of the estuary" (Anon. 1986).

The Fraser River Estuary Management Program (FREMP) was officially started in October 1985. It followed eight years of work which had produced the Fraser River Estuary Study, a report recommending a management program to the federal and provincial governments, and "An Implementation Strategy for the Fraser River Estuary Management Program" released in 1984.

Solutions to the problems were recommended in the study reports (Anon. 1979) and included control measures (on sources, disposal of sludge and hazardous wastes, more advanced treatment at specific sewage treatment plants, control of direct industrial discharges, investigation of accidental and unregulated discharges) and monitoring programs (on storm water, receiving waters, municipal effluents, dilution zones of particular plants, leachates, and aquatic biota).

The Management Program has three interrelated components: goals and policies, management committee, and program activities. Program activities to be started include: coordinated project review (of proposed projects and activities in the estuary), activity programs (dealing with estuary-wide issues), a water quality plan (development of specific ambient water quality objectives and a monitoring program), information systems (for management and the public), area designation (maps defining categories of uses for reaches of the estuary), and area plans (for land and water) (Anonymous 1986). It

should be evident that FREMP is currently the only comprehensive framework and set of plans for marine protection in Canada.

Other Areas

Other geographic areas require comprehensive, integrated approaches. Some of these are essentially marine such as the Grand Banks, Georges Bank and Lancaster Sound with coastal involvement. Others have a primarily coastal orientation such as the Northumberland Strait and the St. Lawrence River Estuary.

ECOTOXICOLOGY - ITS ROLE IN MARINE ENVIRONMENTAL MANAGEMENT

Ecotoxicology has been formally defined as being "concerned with the toxic effects of physical and chemical agents on living organisms, especially on populations and communities within defined ecosystems: it includes the transfer pathways of those agents and their interactions with the environment (Butler 1978).

It is widely accepted that physical, chemical, microbiological and biological procedures together are needed to identify, assess and resolve marine pollution problems. Ecotoxicology has a key role in implementing the various environmental frameworks and strategies to protect and conserve marine environmental quality. A knowledge of the fate and effects of the offending or suspected parameters and substances in the receiving waters is an integral part of the frameworks and strategies discussed above - in particular, the GIPME plan, the Environmental Sensing Strategy and the UNEP Guidelines. It is important to understand what ecotoxicology can do and cannot yet do, in support of marine pollution strategies. It is assumed that for major parameter and substances, their acute and chronic effects on individual organisms and ecosystems in the field are known or can be predicted, and can be monitored with confidence, and that this specific knowledge and capability propels the decisions regarding assessment, control and followup monitoring.

A number of points can be made about the role of ecotoxicological tests and procedures in marine pollution research, assessment, control and monitoring:

1. "The basic objective of applied ecotoxicologists is to place the right numbers and kinds of tests with ecologically significant test species into a worldwide systematic program to enable an early, cost-effective prediction of hazard at an acceptable level of certainty to guide regulatory and industrial decision-making" (Maki 1983).

2. Ecotoxicology contributes to the identification of problems, hazard assessments, the setting of environmental quality guidelines and objectives, the decisions to intervene through various mechanisms, and determining how efficient the controls have been (through surveillance and monitoring).

3. The rationale for hazard assessments and monitoring of marine contaminants, both involving marine ecotoxicological tests, includes the questions - Is the material acutely toxic at the concentration at which it is released? What factors affect the toxicity of the material, and what is the effect of treatment on the toxicity of discharges? Is the material persistent, toxic and bioaccumulative after release to the environment, or is it changed to other materials which may be persistent, toxic and bioaccumulated? What is the nature of the non-lethal adverse effects (especially reproductive, growth, developmental, behavioral, genotoxic, carcinogenic, etc.) of the material on biota, and at what concentrations do these occur? (MacGregor and Wells 1984).

4. There are many kinds of marine ecotoxicological procedures (see Persoone et al. 1984). There is a need for agreement on suites of procedures to apply to specific problems, and a need to standardize and intercalibrate procedures. Considerable progress has been made through ASTM and OECD initiatives.

5. Procedures vary from simple, single-species screening tests to more complex, costly and realistic mesocosm and in-situ effects monitoring procedures, as shown in Tables 1 to 3, organized per the Environmental Sensing and Toxic Chemical Management Frameworks.

6. Batteries of tests can be applied at the hazard assessment and monitoring stages of the various protection frameworks, to ensure detection of compounds that are persistent, bioaccumulative and toxic (i.e. those that should be controlled on a priority basis).

7. The science, techniques and applications of ecotoxicology are evolving very rapidly and will continue to contribute to the resolution of marine problems (see Persoone et al. 1984 and Waldichuk 1985a,b).

8. Some of the needs in marine ecotoxicology, which would support the objectives of the various frameworks and strategies on marine environmental quality, are shown in Table 4.

At present, the capability of the ecotoxicology field should be stated accurately (and not overstated) to enviornmental managers.

Impact assessment

The application of these strategies requires more effective use of baseline data collection, ecotoxicological studies and monitoring programs. But it also involves appropriate use of environmental impact assessment at both the strategic or regional level and the project or local level. We are more familiar with the use of project specific impact assessment in Canada. Figure 4 describes a strategic process intended for use in geographic areas undergoing or likely to undergo significant change. It would provide developers, regulators and the public with a clearer policy framework and a better understanding of coastal and marine use and user conflicts.

Water quality guidelines and standards

It should also be clear that at least some of these strategies and instruments can only be implemented if scientific criteria regarding the effects of contaminants on marine life combined with water quality guidelines, reflecting the preferred uses of the receiving environment, are available. Considerable work has occurred internationally on marine water quality guidelines (Wells et al. 1986). Guidelines are defined as "numerical concentrations or narrative statements recommended to support and maintain a designated water use" (M. Taylor, pers. comm.). The UNEP Montreal Guidelines (1985) environmental protection framework contains two control strategies requiring marine water quality "standards" or guidelines i.e. the strategies based on use and environmental objectives. "Setting objectives for estuarine and coastal water quality first requires having generic guidelines for the process and parameters involved" (Wells et al. 1986). Such guidelines are key instruments in the assessment and control of land-based pollutants, and depend upon marine ecotoxicology in their production.

Environmental monitoring

Monitoring is a key activity of the frameworks and strategies discussed above. Monitoring "can be defined as the measurement of a pollutant or its effects on either man or elements of the marine resources for the purpose of assessing and controlling exposure to that pollutant" (UNEP 1985). Monitoring includes surveys (single sets of observations or measurements which will assess the situation at one particular time) and surveillance (repeated surveys which will indicate changes with time); in its

Table 1

Ecotoxicology - its role in the management of toxic substances

Ecotoxicological Test or Approach	The Management of a Toxic Substance			
	A. Identification of Problem	B. Hazard/Risk Assessment	C. Interventions (eg. controls)	D. Efficiency of Interventions
1. Laboratory, single species tests - acute/chronic	Basic ecotoxicity of a chemical or formulation Testing for approval	Screening for toxicity	Testing and retesting of emissions/discharges.	
2. Microcosm Tests - lab - field	ASSESSMENT		MONITORING	
3. Field Testing - in-situ tests to biomonitoring in unpolluted and polluted ecosystems	Monitoring of "environ. quality" and "ecosystem health"	Setting of Environmental Quality Objectives and Standards * Setting of Emission Standards	Shorter-term applied monitoring	Monitoring of "environ. quality" and "ecosystem health"
	MONITORING			
4. Field Verification (observations of polluted ecosystems)	MONITORING			MONITORING

Table 2

Ecotoxicology and the Management of Toxic Substances - problem identification and hazard assessment

General Category of Test or Approach	Specific Tests	Examples
1. Single-species test - acute and chronic	. QSAR	Daphnia, HC's
	. accumulation expts.	Macoma, contam. sed.
	. screening for new products	Artemia, Amest test, trout
[MOST RESEARCH HAS BEEN DONE HERE]	. fish life cycle tests	Jordanella
	. combined tests - OECD	Algae-Daphnia-Microtox-fish
	. Sublethal growth, development	Marine zooplankton
2. Microcosms - laboratory and field	. Expt'l microcosms - marine	CEPEX, MERL.
	. Limnocoral expts.	Univ. of Guelph - pesticides
	. small-scale microcosms for fate/effects modelling	CCIW, with fish U of T, with Daphnia Bedford Inst., HC's
3. Field Testing - in-situ bioassays, to field biomonitoring of species and ecosystems	. contaminated sediments - tray studies with clams	Petroleum hydrocarbons
	. in-situ salmon expts.	Pulp mill effluents
	. behavioral studies with tagged salmon	Miramachi River, N.B.
	. New York Bight - genetic and physiological studies with zooplankton	Municipal sludge
4. Field Verification - observations of polluted ecosystems	. tumors in fish in N.A. rivers, lakes	Great Lakes
	. oil spill studies	Arrow, N.S.
	. pesticide monitoring studies	N.B.
	. expt'l oil spills	Baffin Island Oilspill Project

Table 3

Ecotoxicology and the Management of Toxic Substances -
Interventions, including specific controls, and Efficiency of Interventions

General Category of Test or Approach	Specific Tests	Examples
1. Single-species tests - acute and chronic	. guideline, regulatory toxicity tests	Rainbow trout Lethal test
	. studies of non-lethal effluents	Oil refinery study, Ontario
	. dispersant guidelines	Rainbow trout test
	. in-plant biomonitoring	Fish behavioural tests
[MOST STUDIES HERE]	. bioaccumulation test for harbor dredging spoils	Macoma test
2. Microcosms - laboratory and field	. behavioral studies	Pulp mill effluents, B.C.
3. Field testing - from in-situ bioassays to field biomonitoring	. physiological - reproduction tests	Striped bass, Ca.
4. Field verification - observations of polluted ecosystems	. oil spills - efficiency of clean-up	BIOS spill, Canada Amoco Cadiz, France
	. intertidal zones, marshes near refineries - ecological studies	U.K.

Table 4

Some Needs in Marine Ecotoxicology to Support
The Control of Land-Based Pollutants

I Identification of problems and approaches
- priority issues and chemicals
- critical habitats

II Baseline studies
- biology of test organisms
- characterization of marine ecosystems

III Testing protocols
- standardization
- extrapolation

IV Predictive tests
- short term toxicity tests
- quantitative structure activity studies
- bioavailability of major pollutants
- sediment evaluations: fate and effects
- comparative toxicology
- studies of mixtures
- ecosystem tests

V Monitoring
- indicators of ecosystem health
- regulatory monitoring
- trend analysis
- population impacts

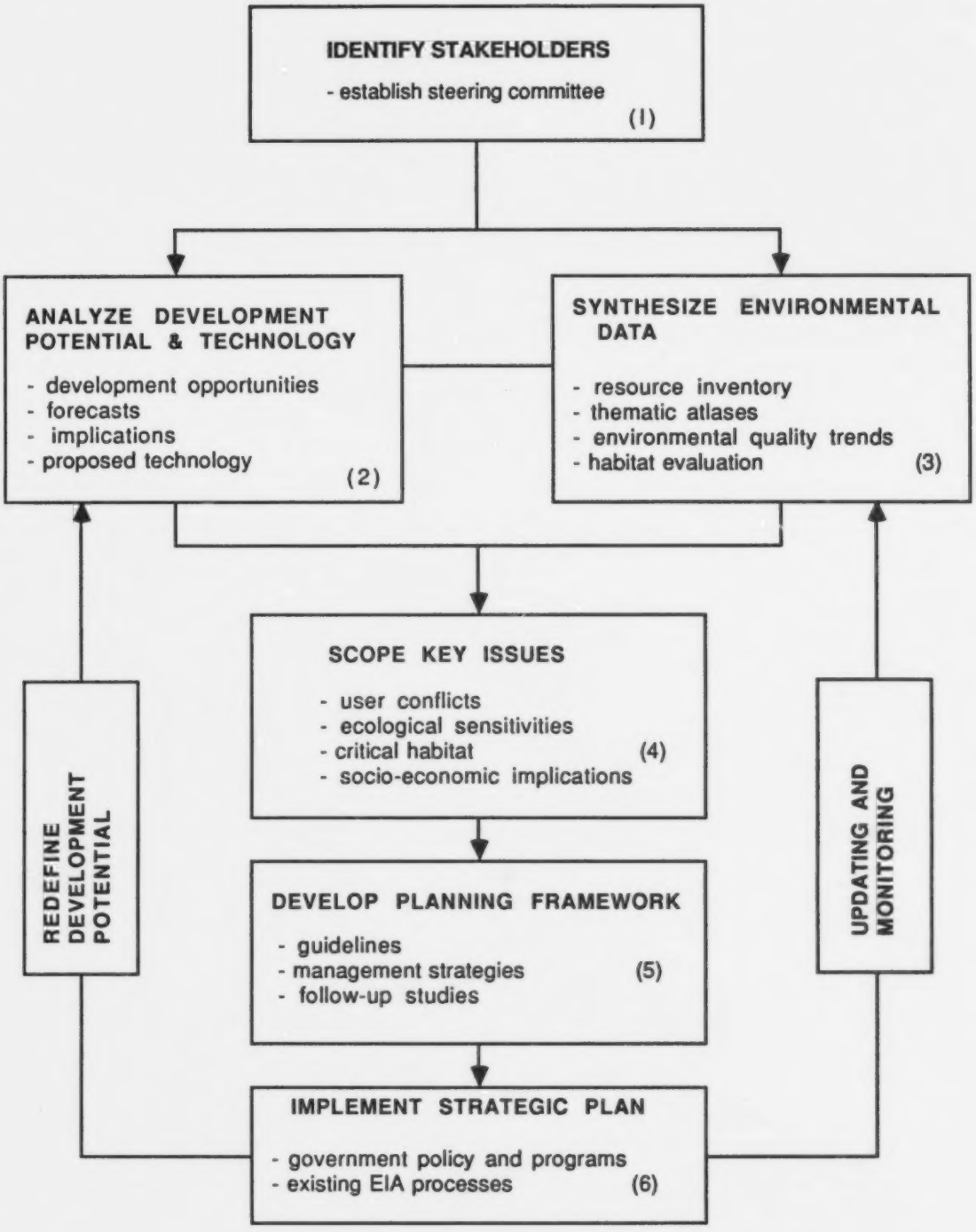

Figure 4. Strategic Impact Assessments

restricted legal sense, monitoring indicates repeated observations or measurements that check whether that which is studied conforms to an already-stated standard (Moriarty 1983).

As shown in the environmental protection framework of the UNEP (1985) Guidelines, specific types of monitoring are required for identifying and assessing a problem at source and under ambient conditions, and for ensuring the effectiveness of chosen control strategies and instruments. Monitoring can include both chemical and biological effects monitoring, both being necessary for ensuring the protection of biological resources and human health.

As an example, monitoring is recommended for the management of the Fraser River Estuary - monitoring storm waters, receiving waters, municipal and industrial effluents at source, dilution zones near major discharges, and aquatic biota throughout the estuary (Anon. 1979).

Effects monitoring, where the condition of biota are measured systematically over time using suites of biological and biochemical techniques, is based upon the principles and procedures of marine ecotoxicology. Choice of species and response parameters, influence of modifying factors, and interpretation of the responses measured in effects monitoring all come from the continued research and development in marine ecotoxicology.

CONCLUSIONS

Management of hazardous and solid wastes must be put into a comprehensive protection framework in order to adequately protect the uses and qualities of marine waters. A number of national and international agencies such as UNEP have already produced such frameworks to improve decision-making and to bring relevant jurisdictions and parties together.

One such framework, the UNEP Guidelines for the Protection of the Marine Environment Against Pollution from Land-Based Sources, clearly presents the strategies and control options that parties must consider to reduce serious marine contamination. At the present time in Canada, only one program is in place which follows the concepts elucidated in the comprehensive frameworks described in the paper. This is the Fraser River Estuary Management Program. Many other marine geographic areas in Canada require similar approaches.

An important component of all these frameworks is a reliable understanding of the fate and effects of the substances and wastes discharged to coastal and marine waters. That is to say that marine ecotoxicology has a crucial role in the choice and implementation of effective management strategies and control options. In particular, ecotoxicology is a critical part of environmental impact assessment, the derivation of water quality guidelines and appropriate monitoring programs.

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The Dalhousie Dredged Material Containment Facility

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ABSTRACT

National and international concern for the protection of the marine environment led to the establishment of various international conventions (e.g., the London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter) and the enactment of national/provincial legislation. These conventions and Acts were designed primarily to regulate the disposal of hazardous chemical and industrial wastes and sewage sludges, but they also control the disposal of dredged sediments.

Increasing concern for the impact on the marine bio-resources of the lead, zinc and cadmium in the dredged materials (due to spillage during ore-loading) in Dalhousie, N.B. led Environment Canada to require that Public works dispose of the material in a small inter-tidal embayment adjacent to the port. This mode of disposal proved to be poor and was considered to have a greater impact then open-water disposal, thus a confined disposal facility (CDF) was constructed.

Prior to 1978 the dredged sediemnt was disposed at an open-water site approximately 15 km to the east of the part in the Baie des Chaleurs.

The berms for the CDF were made from bark and log material generated as wastes by the pulp and paper mill. This material proved to be a highly beneficial use of waste, as it provided a cheap but efficient berm material, did not place excessive leading on the soft underlying sediment of the site and provided a highly absorbent material to effectively stop berm infiltration by water from the dredged materials.

Monitioring of the operation of the CDF was conducted in 1982-83 during the first year of operation. The suspended particulate matter and trace metal content (Cd, Cu, Pb, Zn and Hg) of both the inflow and effluent of the facility were determined.

The facility was found to operate extremely efficiently with a 10^3 -10^5 reduction in concentration of suspended solids and thus total metal concentration. The dewatering effluent "matched" the water quality of the receiving waters. This was the first, and to-date, biggest CDF in the Atlantic region. The construction and operation of the facility have proven to be an excellent management of contaminated materials.

BACKGROUND

Canada, as a signatory to the International Convention on the Dumping of Wastes in the Sea (London Dumping Convention), enacted the Ocean Dumping Control Act (ODCA) in 1975. The purpose of the Convention and the Act is to provide a mechanism to regulate the disposal via dumping of waste materials in the marine environment. Although designed primarily to control the disposal of chemical and industrial wastes, the Convention and the Act also cover the disposal of dredged sediments.

In Canada approximately 90% of the some 300 Permits issued annually are for the purposes of ocean disposal of dredged sediments. Of the 2000 ports and harbours in the Atlantic region, some 500 have been dredged at least once since enactment of the ODCA. Because many of these projects are relatively small in size, the cheapest form of disposal has been ocean disposal. Thus the ODCA has

played an important role in the development and operation of the Atlantic region harbours.

The port of Dalhousie, N.B., lies at the mouth of the Restigouche River where is enters the Baie des Chaleurs, an arm of the Gulf of St. Lawrence (Figure 1). The port serves the north-western part of New Brunswick, with principal shipments being paper products and lead-zinc ore concentrate. Natural siltation has led Public Works Canada to dredge the navigation channel and dock area, particularly of the West Wharf area

Prior to 1972, dredged materials were dumped at a variety of locations based on convenience to the dredge operator. Concern with potential mercury contamination from a local chlor-alkali plant lead Environment Canada to require that the materials be dumped at a site in the western basin of the Baie des Chaleurs approximately 15 km east of Dalhousie (Figure 1) (Eaton 1973). This site was used to 1978 when increasing concern for the lead, zinc, and particularly cadmium content of the sediments (analyses required under the ODCA) Figure 2 MacLaren Marvex, 1979a) led Environment Canada to require that Public Works Canada dispose of the materials in a shoreline site where the materials would not be subject to possible off-site transport and therefore contamination of bio-resources. From 1978 to 1980, Public Works dumped the dredged materials in an inter-tidal area to the west of the West Wharf (Figures 3 and 4).

This West Bay site was only considered temporary with possible re-use of the open-water site. However, on the basis of various studies (e.g, MacLaren Marex, 1979b; 1980a,b; Plansearch, 1981; Martec 1982) Environment Canada indicated that disposal at the original open-water site was unacceptable. Continuing pressure from local users for dredging led Public Works to construct a confined disposal facility (CDF) in West Bay in 1983. The purpose of this paper is to report on the facility and the associated environmental monitoring.

DESCRIPTION OF FACILITY

The CDF was built in the West Bay area (Figure 5) which had been used for disposal between 1978 and 1980. The bay originally contained large quantities of soft silt and decomposed wood materials all of which had been contaminated by wind-blown dust and run-off from the adjacent ore piles. The 1978-80 dredged materials were similar in geotechnical and chemical properties.

To overcome the problem of constructing berms on such sediments, Public Works used waste bark and wood reject materials from the local pulp and paper mill, which otherwise was being dumped on the shore of East Bay. This material proved to have several advantages:

- ready access of large quantities;
- low cost of purchase;
- ease of access for transportation of the construction materials;
- ability of the materials to be shaped into berm structures;
- the density of the material was such that it did not cause undue compression on the original supporting silt and therefore did not require pre-construction excavation of the original silt;
- the material would act as a natural filter fabric;
- cost comparison was $2.50/cu.m. for the mill waste versus $8.00 per tonne for rock delivery and placement.

The facility was designed following the guidelines of Palermo et al., (1978) with three cells. The material was to be loaded into cell 1 with the water and suspended solids allowed to flow through cells 2 and 3 before re-entering the estuary. Each weir consisted of 3 inch gravel to prevent erosion of the mill waste. The gravel also further reduced water flow velocity. The flow pattern was designed to maximize the horizontal transport time to permit complete settling out of the materials suspended by the dredging and disposal operation.

The facility was designed to a capacity of 275,000 cu. m. of material over an area of approximately 10 hectares. Because the areas proposed for dredging had not been dredged in three years, the initial project was for 120,000 cu. m. with material coming from both the West and East Wharf areas. In 1984 a similar but smaller facility was built in East Bay. This paper will report on the monitoring of the West Bay facility during the first year of use of the CDF.

MONITORING

Sampling

We were contracted to analyze a series of water and sediment samples during the first year of operation, 1982-83. Water samples were collected by Public Works Canada staff under our direction at the inflow, outflow at weir 1, outflow at weir 2 an at a site upriver of the project designated as "background. Water samples were collected daily, filtered both the filtered seawater and the collected suspended particulate matter (SPM) for total mercury, cadmium, copper, lead, and zinc.

In addition, sediment samples were taken periodically from the various dredge cuts and analyzed for cadmium, copper,lead, zinc, and mercury to provide a comparison to earlier pre-dredging grab and core data.

Analysis Methodologies

Water samples were vacuumed-filtered through 0.4 micron Nuclepore filters. The filters with SPM were dried and weighed to obtain the unit weight of SPM per litre of water. The SPM and the sediments were dried and digested in hydrofluoric/nitric/hydrochloric acids with analyses by flameless (Cd, Pb), flame (Cu, Zn) or cold-vapour (Hg) atomic absorption spectroscopy. The filtered seawater samples were extracted with APDC-MIBK and analyzed by flameless atomic absorption spectroscopy. (Loring and Rantala, 1977; Walton, 1978).

RESULTS AND DISCUSSION

Table 1 lists some of the concentrations in sediments; Table 2, concentrations in the water samples.

TABLE 1
ANALYSIS OF DREDGED MATERIAL DURING OPERATION (mg/kg Dry Wt.)

CD	CU	PB	ZN
2.22	31.1	52.5	932.
1.24	29.6	42.0	573.
1.51	16.6	8.87	407
2.04	22.4	17.6	822

TABLE 2
TOTAL SUSPENDED SOLIDS (mg/L)

INFLOW	WEIR # 1	WEIR # 2	SEAWATER BACKGROUND
20600	-	19	4
36300	26	-	-
37500	11800	-	624
14500	-	36	-

TOTAL METAL (μ g/L)

	CD	ZN	CU	PB
INFLOW	28	13000	611	1100
	109	33150	1150	2300
WEIR # 1	0.29	28.2	2.86	17.0
	21.6	6420	472	576
WEIR # 2	0.95	33.7	2.83	4.21
	1.51	124	5.51	16.4
BACKGROUND	0.03	4.86	0.31	0.91
	178	13700	860	3100

Typical sediment concentrations of cadmium, the metal of concern, were 0.6-2.0 mg/kg or in excess of the Ocean Dumping Control Act guidance level of 0.6 mg/kg (e.g. Plansearch, 1981). Concentrations of lead and zinc were also higher than typical for Atlantic Canadian harbour sediments (lead: 50 mg/kg; zinc: 120 mg/kg; OceanChem 1984, 1985a,b).

Analysis of the filtered seawater indicated that very little of the overall total concentration of the metals existed in the dissolved phase. There had been some initial concern that the suction dredging operation or the large volume of interstitial water in the sediments would lead to leaching from the sediments into the associated waters.

Analysis of the SPM indicated that monitoring of mercury and copper was unnecessary.

Analysis of the SPM for cadmium, lead and zinc indicted that the absolute concentration of metal per unit weight of SPM did not change compared to the inlet samples or to the "background" sample. Rather, it was the significant decrease (typically 1000-10,000 times) in total weight of SPM which lead to a decrease of total cadmium, lead or zinc per unit volume of water sampled. The decrease in total metal was a direct function of the efficiency of the CDF. Comparison of weir 1 and weir 2 samples indicated that approximately 90-95% of the removal mechanism was occurring in cell 1. A similar removal efficiency in cell 2 thereby further reduced the total metal concentrations to the level observed in the upriver "background" samples.

Table 3 gives a comparison of results from this monitoring program to results from various laboratory studies (Hoeppel et al., 1978; Yu et al., 1978) and marine receiving water quality criteria, as set by the U.S. Environmental Protection Agency and the State of California (Chen et al., 1978). The results of this study were well within American regulatory criteria. Results were less than or comparable to the field leachate average results with the exception of lead. However, the average lead in the Restigouche estuary was also much higher than "typical" seawater concentrations. This is likely due to the high loading of SPM in the estuary and both anthropogenic and natural high levels of associated metals.

TABLE 3
COMPARISON OF EFFLUENT CONCENTRATIONS TO AMERICAN STUDIES
(TOTAL METAL, µg/L)

Parameter	Cadmium	Copper	Lead	Zinc	Mercury
This Study					
Weir # 2	0.27	8.14	43.5	161.	16.
Seawater	0.40	5.21	36.8	103.	2
American Studies					
Brackish Water Site Effluent	32.	480.	1820.	2630.	8.3
Lab Leachate Average	10.5	12.5	94.8	128.	7.6
Field Leachate Average	4.	41.	1.40	410.	0.3
EPS Marine Rec. Water Criteria	100.	0.01x $96LC_{50}$	0.02 x $96LC_{50}$	100.	100.
State of California Marine Rec. Water Criteria	30.	300.	200.	500.	0.2

(Ref: Chen et al., 1978).

CONCLUSION

We recommended that future monitoring be reduced to analysis for cadmium, lead and zinc in SPM and measurement of total SPM in the inflow and the outflow (at the outermost weir).

Public Works Canada estimated a design requirement of 890 minutes to achieve the removal of suspended particulate matter to the level estimated for the Restigouche estuary, based on the calculations of Palermo et al., (1978). Although no flow measurements were made, the geochemical monitoring data indicated that environmentally-acceptable removal of SPM and the associated metals was accomplished.

This project showed that design and proper construction and operation of a large CDF could be undertaken in the Atlantic region. The novel use of mill waste proved to be beneficial in reducing project costs and in using an otherwise waste material requiring disposal. Third, the facility met all environmental requirements and the CDF enabled the dredging of the port of Dalhousie to be undertaken in an environmentally acceptable fashion.

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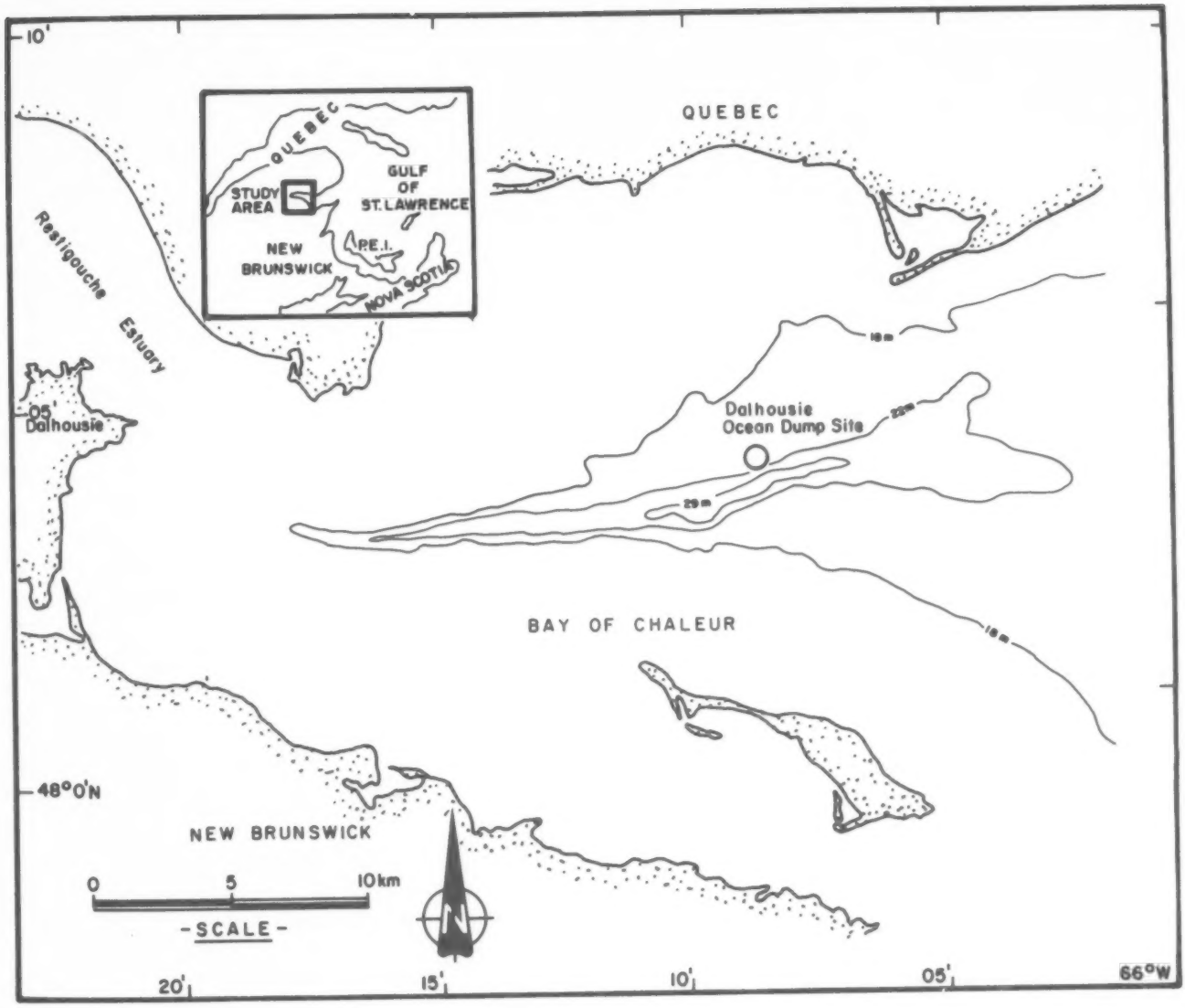
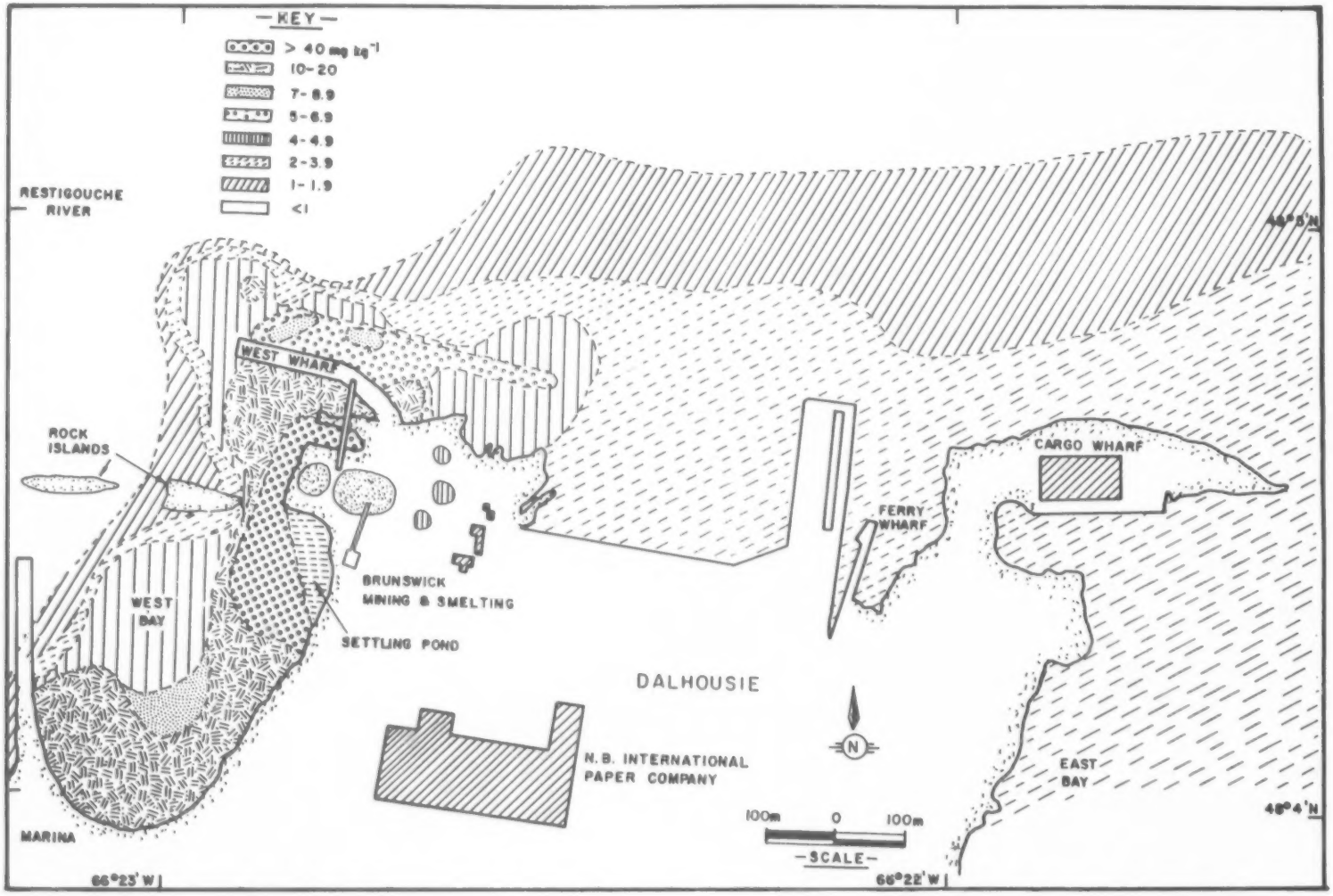
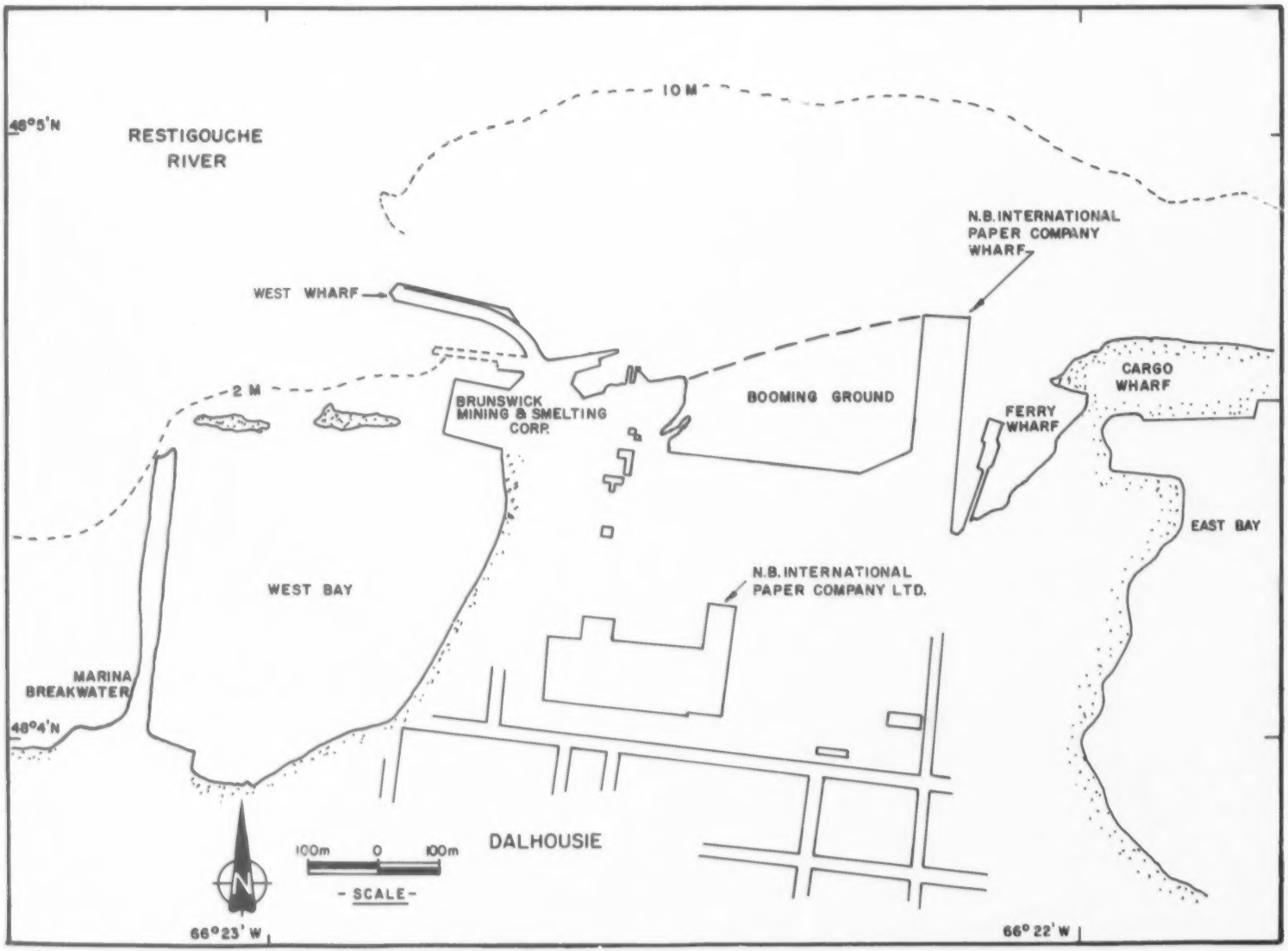


FIGURE 1 DALHOUSIE OCEAN DUMP SITE (1972-78)



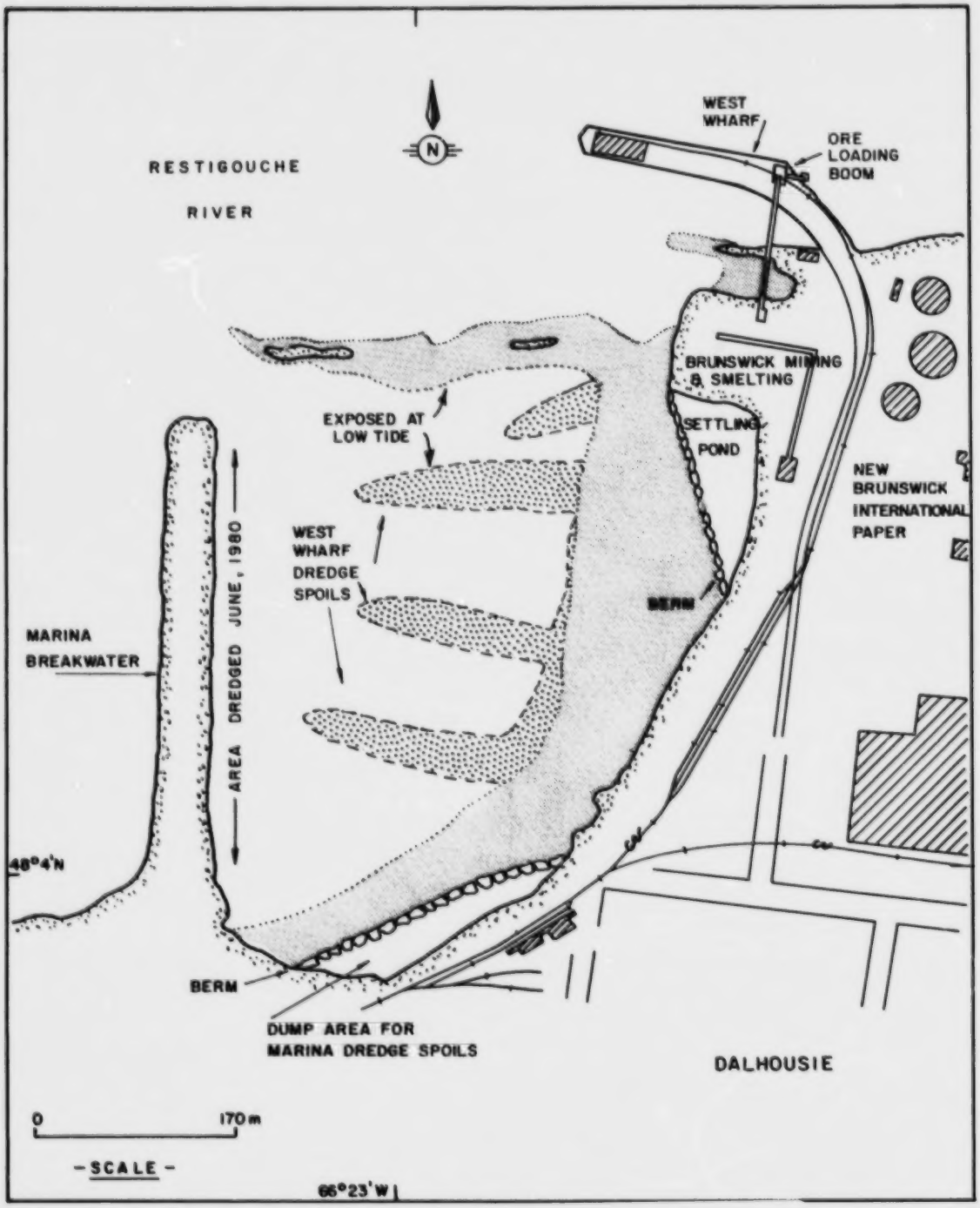
CADMIUM DISTRIBUTION IN DALHOUSIE HARBOUR SEDIMENTS

FIGURE 2



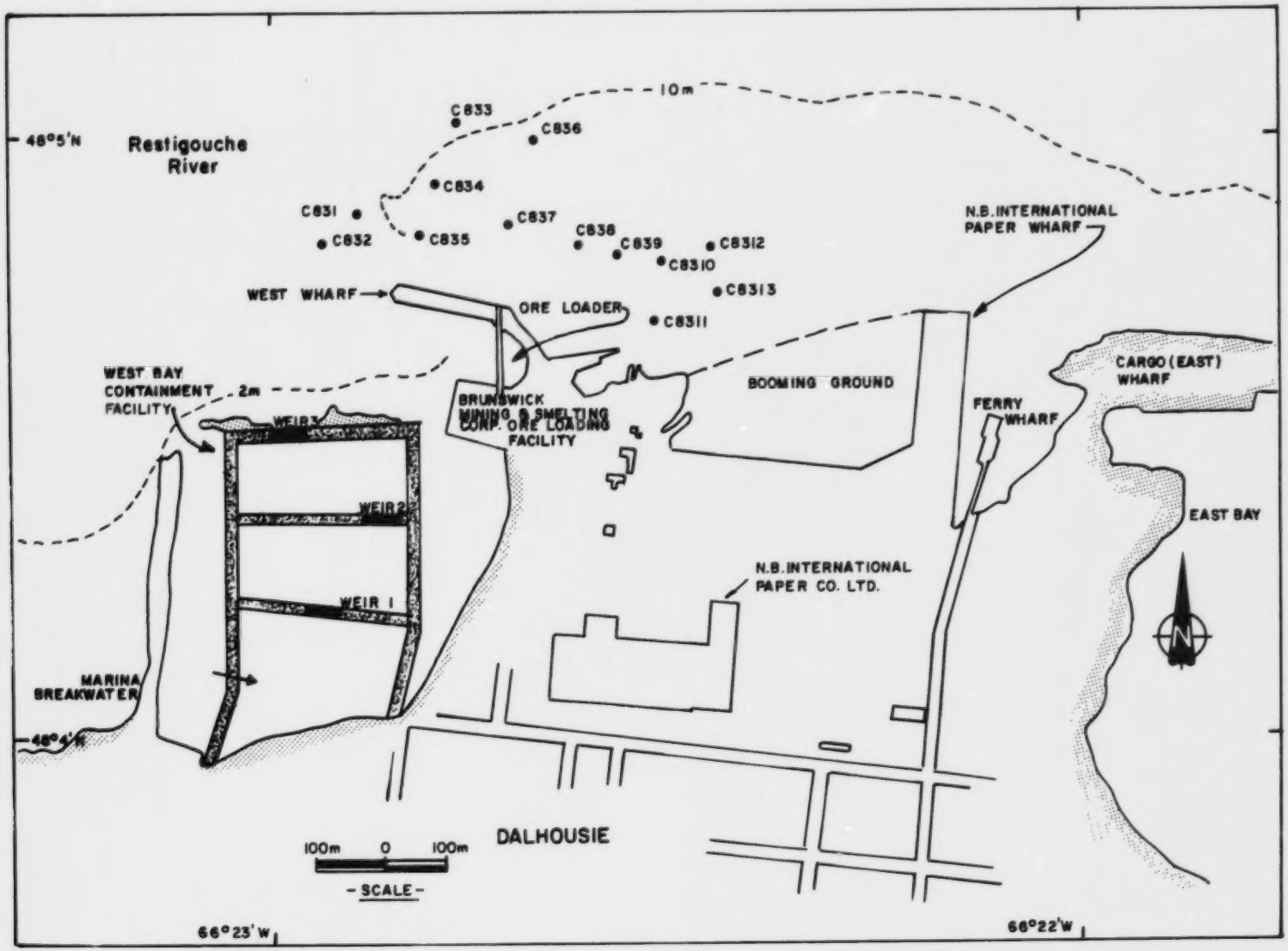
DALHOUSIE HARBOUR (1978)

FIGURE 3



WEST BAY DISPOSAL AREA
(1978-1980)

FIGURE 4



DALHOUSIE HARBOUR AND CDF
(1983)

FIGURE 5

CONFLICT RESOLUTION AND MANAGEMENT IN OCEAN DUMPING OF WASTES

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ABSTRACT

Under the authority of the Ocean Dumping Control Act (1975) Environment Canada regulates the dumping of wastes in the ocean. Maximum permissible levels of contaminants have been established and a means to control disposal timing and procedures exists through a permit system. A Regional Ocean Dumping Advisory Committee (RODAC) resolves concerns related to conflicting uses of the environment and provides guidance to managers. Research is sponsored to resolve questions related to toxicity and impacts and to aid in the decision making process.

Uniformity of approach is achieved nationally through annual meetings held in Ottawa. Consistency with the objectives of the London Dumping Convention is assured by representation at the international steering and scientific meetings.

The effectiveness of this management approach has been demonstrated and should be extended or emulated to control other pollution sources in the marine environment. A holistic approach to marine environmental protection is endorsed.

INTRODUCTION

Canada, along with more than fifty other countries is a signatory to the London Dumping Convention (1975) on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter. This is an agreement between nations to control the dumping of wastes at sea both in their national waters as well as on the high seas. A committee meets annually so that each participating nation can report on its dumping activities and recommend revisions of the convention to maintain its effectiveness. A scientific subcommittee was also established to identify substances of concern and to advise on maximum contamination by these substances which can be accepted as environmentally safe, and to evaluate the effectiveness of recommended procedures.

In fulfilling her commitment to this convention, Canada has promulgated the Ocean Dumping Control Act (1975) which has proved to be an effective legislation for regulating the disposal of wastes in the ocean. By establishing limits of contamination and by requiring chemical and physical analysis of candidate material for dumping, an effective means for control has been established. Coordination of the evaluation of the nature of material for disposal and intentions of the applicant is carried out by a Regional Ocean Dumping Advisory Committee (RODAC). When appropriate the RODAC also solicits input from the public and other users of the Marine Environment that may be affected by the proposed dumping. In this manner social as well as environmental issues are addressed.

RESOLUTION OF OCEAN DUMPING REQUESTS

The day by day administration of ocean dumping control is managed by the Environment Canada Conservation and Protection and in the Atlantic Region by the Marine Environment Branch, of that service. The movement of a permit application through the review system takes about six weeks and is summarized in the following figure. (see fig. 1)

The Regional Ocean Dumping Advisory Committee RODAC has been the single most effective mechanism in resolving potential conflicts between proponents, other resource users and environmental and resource protection agencies. No permits are issued without the concurrence of RODAC members. RODAC members are drawn from the Department of Fisheries and Oceans and the Environment Canada and each RODAC member is a point of contact for a number of experts in Ocean Sciences or Fisheries Management as well as a contact with fishermen. The Environment Canada RODAC members are also the point of contact for other federal services such as Transport Canada, Public Works or Ports Canada as well as the liason between provincial government departments, proponents and the public.

It should be understood that the Ocean Dumping Control Act is very specific in its definition of ocean dumping. It controls only the disposal of material from barges, vessels, aircraft or from ice. It also includes incineration of materials at sea for the specific purpose of disposal of wastes. It does not include operational discharges from vessels or oil rigs nor does it include effluents from land based sources or shore line infilling. These sources of pollution are regulated under other federal, provincial, or municipal legislation and are not necessarily even under the direct control of Environment Canada. This is perhaps a weakness in our present administration.

The ocean dumping control system does not seek to duplicate the Environmental Assessment and Review Process EARP required of all federal developments and recommended whenever federal dollars are involved (such as offshore oil and gas projects or other major developments like highway construction or power projects such as the Le Preau Thermo-Nuclear Plant. Rather it seeks to complement such processes. For examples small-craft harbour development proposals are reviewed internally using the EARP screening guidelines by the relevant department, in this case Fisheries and Oceans. Disposal of dredge spoils in an environmentally acceptable manner is then carried out under the permission of Environment Canada based upon the advice gathered and provided by the Regional Ocean Dumping Advisory Committee. (RODAC)

A philosophy for the management of the ocean dumping has evolved since experience has taught us that ocean disposal can not be considered in isolation from other disposal alternatives such as land fill, onshore dumping or containment behind a berm. Efforts have focused upon identifying the least costly, environmentally acceptable solution to waste disposal. For marine sediments, such as dredging spoils originating from the deeping of channels or the construction and maintenance of ports and harbours, the least costly solution is almost invariably marine disposal.

More than eighty percent by volume of material ocean dumped is, in fact, dredge spoils. Contamination of these sediments is generally a result of harbour activities such as ship building, product storage mishaps, engine repair and maintenance, sewage contamination, accumulated fish wastes, poor housekeeping practices and deliberate misuse of harbours for nefarious disposals. Authority for control of the disposal of these sediments has, as already stated, been established with the Ocean Dumping Control Act and is managed regionally by means of permits issued on behalf of Environment Canada by the respective Regional Directors of the Environmental Protection Service. It is unfortunate that the initial contamination of these sediments is not as yet equally vigorously controlled.

The criteria for the acceptability of material for marine disposal are sufficiently clearly defined that outrageous requests for disposal are seldom received and therefore dumping applications are seldom rejected outright. The control lies in the selection of appropriate dumpsites and in ensuring that the impact upon the environment and conflict with activities of other uses of the environment is minimal.

This is achieved by ensuring that, where possible, that sediments are disposed in areas of similar grain size and consistency and that contaminated sediments are disposed of in equally contaminated areas, or in a manner which renders them harmless to the environment, such as burial in the sea floor and capping with clean sediments or by containment on the foreshore so that no increase in degraded sea-bed or water quality occurs. Short term impacts are minimized by the use of silt screens, where appropriate, or, in the case of liquid disposals, by pre-disposal dilution so that in all cases, the waste is rapidly rendered harmless. Timing of disposals to minimize disruption of fish migrations or fishing activities is also practiced and efforts are made to evaluate the effectiveness of controls which are employed. In all cases, the wishes of the proponent, as outlined in his application, are given full consideration so that the ultimate solution to the disposal need is the most economical environmentally acceptable one. Once mutually acceptable terms and conditions are established, these are then written into permits and approval to dump is granted.

To recapitulate, keys to the resolution of conflicts in ocean dumping have been:

1. A clear understanding of the intent and objectives of the applicant.

2. An adequate physical and chemical description of the nature of the material to be disposed and an accurate estimation of the quantity involved.

3. Communication of the intents of the proponent and nature of the material to all concerned parties.

4. Consideration of all social and environmental issues identified, and the institution of a procedure or mechanism to address these concerns.

5. Incorporation of all constraints in the terms and conditions of the permit, or where a permit is refused, constructive alternative solutions put forward.

6. Inspection to ensure compliance.

7. Verification and evaluation to ensure actual impacts are acceptable and if not, that mitigatory measures are taken to ensure that wastes are truly rendered harmless.

I would now like to illustrate my talk with some actual examples of ocean dumping operations where conflicts were resolved.

DALHOUSIE N.B.

In the case of Dalhousie New Brunswick, the subject of the previous speaker's paper, pre-permit evaluation indicated that the greater part of the dredge spoil was unacceptable for ocean dumping, therefore containment in nearby West Bay was recommended. A study carried out by Public Works Canada indicated however that this would be prohibitively expensive. Environment Canada funded an additional study which recommended an acceptable interim disposal alternative whereby West Bay was dredged and the spoils side-cast, thereby creating pits into which the less stable dredge spoils from the harbour area could be dumped. The side cast material proved stable enough to form the foundation for berms made of readily available wood fibre waste and faced with rock and ultimately a relatively inexpensive enclosed containment was constructed.

To achieve an acceptable solution it was necessary to negotiate not only with the companies involved, Brunswick Mining and Smelting, and the International Paper Co. but also with the department of Public Works, which at that time was responsible for the port maintenance, a local boat club with property in West Bay, the mayor of town Dalhousie and the Regional Development Coordinator as well as our sister department of Fisheries and Oceans. The net result was an acceptable long term solution for spoil disposal, an improved site, and an evaluation of the impact of previous ocean disposal activity.

SAINT JOHN HARBOUR N.B.

Saint John Harbour was also cited in an earlier paper as an area which presented a potential conflict between fishing interests and the need to maintain the port for shipping. Meetings with the fishermen were held and the results of research related to rates of sedimentation were presented. Additional studies of sediment movement in and out of the harbour areas from tidal and fluvial activity, were funded to augment the data submitted by the proponent of the dredging operation. As a result of these studies, the relatively small impact of the dumped material, when compared with other factors, was demonstrated and a better understanding of priorities for the improvement of water quality in the harbour was gained. The suitability of the Black Point dumpsite was confirmed.

MIRAMICHI N.B.

The deepening of the Miramichi Estuary in 1982 and 1983 was the largest single dredging and dumping operation to take place in Atlantic Canada. 4 million cubic metres of spoils were relocated. The management of this project was the primary responsibility of Public Works Canada and the environmental impact was controlled and minimized through the ocean dumping permit process. A special subcommittee of RODAC was formed to evaluate the proposed operation. Predredging assessment of environmental conditions and resource locations was required. An evaluation of the dredge operation and two years of post dumping assessment was also a condition of the permit. Impact assessment included such factors as water quality (dissolved oxygen, suspended sediment, turbidity), chemical analysis of potential spoils, dumpsite selection and monitoring. Major controlling factors were the movement and location of fish and shellfish stocks within the estuary, in particular, the seasonal movement of salmon, smelt, herring and lobsters within the estuary and the location of herring spawn and shellfish beds. Fishing conflicts with activities and claims for compensation, particularly the accidental destruction of fishing gear during dredging were resolved by a separate committee co-established by Fisheries and Oceans and Public Works.

Considerable additional research was funded under the Ocean Dumping Research Fund to address specific issues such as the destabilization of the bottom sediments following dredging, the location of herring spawning beds, and the stomach contents of smelt.

Although the evaluation and control process was not perfect, it nevertheless provided the most comprehensive data base for the dredging of an estuary to date and, in the process of its development, it established a means to evaluate not only the long term impacts of a large dredging operation but also a means of controlling impacts with a twenty-four hour turn around for real time response. This was particularly important when low oxygen levels in the summer coincided with dredging operations which could have been critical to salmon migration and survival.

VESSEL DISPOSALS

Vessels such as old cargo vessels or retired fishing boats can sometimes be disposed of most easily by sinking. Ocean dumping control ensures that oils, grease, cargoes and flotsam are removed prior to disposal to minimize the environmental impact. An ocean dumping permit was also issued when the Ocean Ranger was raised and resunk in a less hazardous location. Conditions for clean up of the original site were stipulated. Our involvement was primarily from the aspect of environmental hazard.

PUBLIC INVOLVEMENT (CANSO N.S.)

On occasion, public meetings, are held when conflicts are anticipated and where public interest is high. The ocean dumping permit system is used to control oil spill experiments when new gear or technology is being tested. The location of such experiments is critical if fishing and environmental concerns are to be minimized. Methods of rapidly rendering the spilled oil harmless either by cleanup or by dispersion are an essential aspect of the management strategy. On occasion, when these criteria were not considered to be achieveable, permission has been refused.

GEORGETOWN P.E.I.

The recent dredging of Georgetown harbour (1985) and disposal of spoils which were contaminated to some extent with PCB's was resolved by digging a pit in the nearby harbour sea floor and, after dumping the questionable material in the pit, covering it with a one metre thick cap of the displaced material and clean sandy material. Subsequent sampling and analysis indicates that the contaminated material was successfully capped and the cap is consolidating. Because of the general public sensitivity to PCB contamination, the town council was much involved and a public meeting and information session was held. The acceptance of the solution of disposal by burial and capping was dependent upon subsequent sampling and monitoring and an assurance to the town that if the cap was not adequate that further action to seal the contaminated material would be taken. The town is now satisfied that appropriate procedures and precautions have been taken.

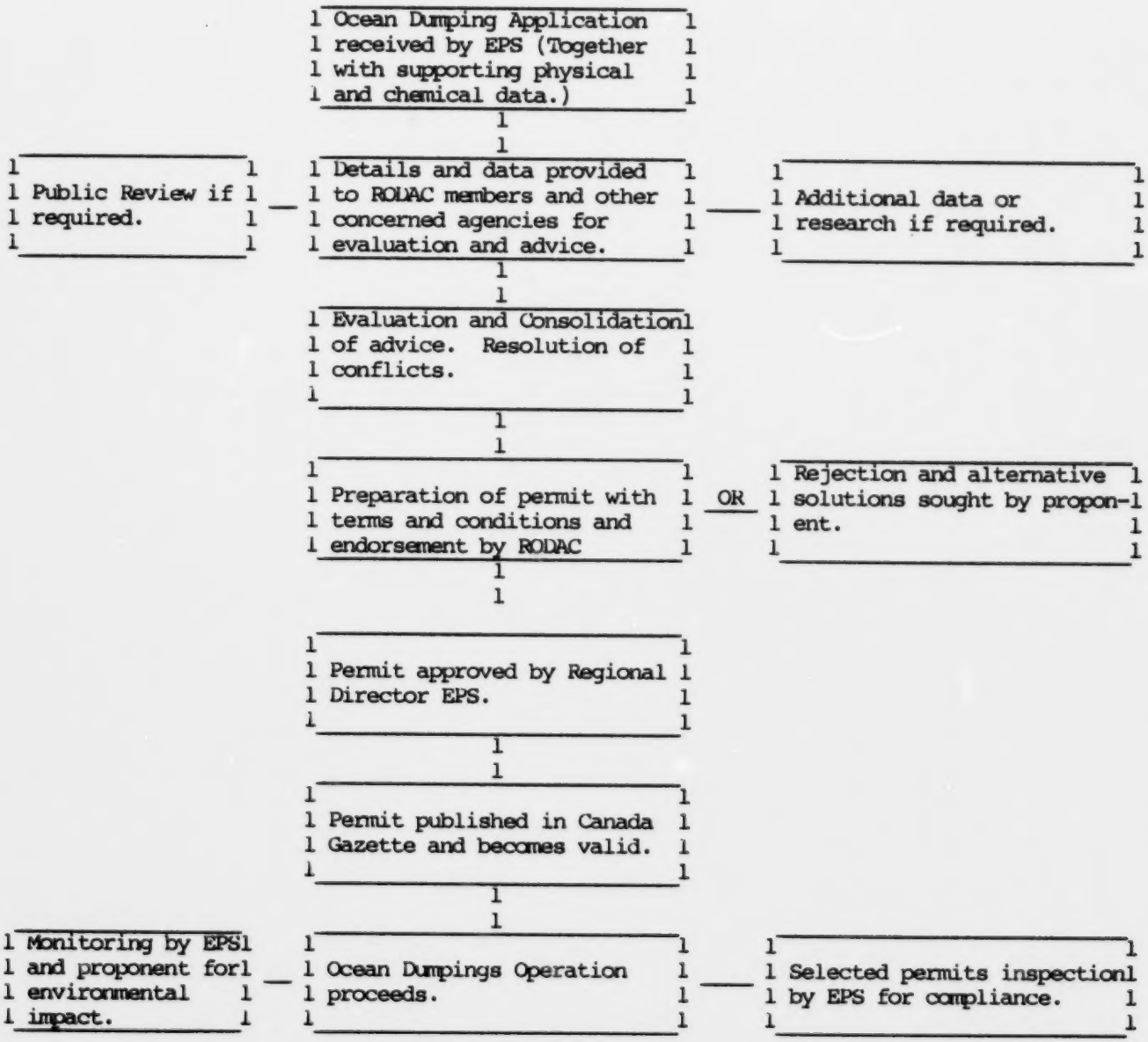
CONCLUSION

The purpose of my talk has been to illustrate that when conflicting uses of the marine environment exist, such as the need for dredging to improve marine transportation channels and harbours versus the needs of inshore or offshore fishermen and shellfisheries, or the need to protect nursery areas and sensitive marine ecosystems from contamination or obliteration, that mutually acceptable solutions can usually be negotiated provided adequate legislation and the political will exist to effect the resolution of issues which may arise. The Ocean Dumping Control Act has established the tolerable limits for the primary contaminants, and has sufficient flexibility to regulate the disposal of substances of questionable acceptability. It also has the power to control the method and timing of ocean dumping and to enforce compliance.

The permit system has proved to be an effective tool in maintaining compliance with environmental quality objectives in the context of Ocean Dumping. Serious consideration should be given to managing the control of other sources of marine pollution by similar means. Interaction between control authorities is vital if an holistic control is to be achieved. The framework for such a mechanism is developing internationally, with the ratification of the London Dumping Convention; Marpol, for the control of marine pollution from vessels; Termpol, for the control of pollution from marine terminals and now, since 1985, the creation of the (United Nations Environmental Program) Montreal guidelines, for the protection of the marine environment against pollution from land-based sources. It remains for Canada to generate reciprocal legislation and an interactive framework for the overall control of marine environmental quality.

TYPICAL APPROVAL PROCESS FOR OCEAN DUMPING IN THE ATLANTIC REGION

FIG. 1



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TREATMENT AND DISPOSAL OF EFFLUENTS FROM OFFSHORE OIL AND GAS EXPLORATION/PRODUCTION SYSTEMS

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ABSTRACT

The waste products of offshore oil and gas operations originate from several sources giving rise to varied treatment problems. Factors influencing offshore waste treatment facilities design are many, including type of platform, weight and space limitations, origin of wastes, environmental conditions, and government regulations. Some of these factors have major influence on the design and make these offshore facilities different from those on land.

This paper deals with major offshore waste disposal problems and the treatments necessary to make these wastes environmentally acceptable for disposal with particular emphasis on the Canadian scene. It describes some of the basic requirements for the disposal of wastes originating on the offshore oil and gas platform. However, designs may vary somewhat depending on the particular situation.

INTRODUCTION

Until recently, all the waste effluents in Atlantic Canada that used to be dumped into the ocean came from two major sources, (i) industrial effluents; and (ii) city sewage. However, a new situation has developed recently due to oil and gas exploration and future production in Canada's eastern offshore areas. Drilling for and production of oil and gas not only produces desirable hydrocarbons but also waste effluents. Waste products from an increasing number of drilling rigs and future production platforms will pose a threat to the marine environment unless suitable remedial measures are implemented in advance. Proper treatment procedures must be implemented to make these waste products safe for the marine environment which is the source of livelihood for many people in the Maritime provinces.

DESIGN CONSIDERATIONS

The basic waste treatment facilities are similar on all platforms. However, the detailed design and the extent of treatment are determined by the quantity and quality of crude and/or gas feed, type of platform, availability of space, environmental conditions and the required quality of discharges into the ocean. The four major sources of waste products from offshore oil and gas activities are, (i) drilling; (ii) platform drains; (iii) produced water; and (iv) sewage.

The type of treatment facilities on drilling, production, and drilling cum production platforms vary. The quality of crude such as water cut, sweet or sour, will affect the drainage. Environmental conditions will also affect the drain system. Manpower requirements will determine the design of the sewage treatment facilities. Local environmental regulations will determine the extent of treatment required, thus affecting the equipment design, chemicals dosing rate, etc. The various waste treatment facilities will be dealt with in the following sections.

DRILLING

In drilling, the substance known as mud is a complex mixture of several chemicals of varying composition and can be water or oil based. Mud serves many purposes in drilling operations including; lubrication, cooling of drill bit, removal of cuttings and as kill fluid for blow out prevention. The drilling mud returning from the well is treated to remove the suspended solids (cuttings) and entrained gases, so that it can be recycled back into the system and the oil free cuttings can be dumped into the ocean. The separation of cuttings, oil, and gas from the mud takes place in several stages.

Fig. 1 shows the process flow scheme for a typical drilling mud treatment system. The returning mud is fed via the bell nipple on to the shale shakers where vibrating fine mesh screens separate the large cuttings from the bulk of the mud which falls through the screen into a sand trap below. If water-based mud is used, the cuttings are dumped directly into the ocean via drilling drains and drilling drains caisson without any further treatment.

The mud from the sand trap passes to the degasser suction pit. From here the mud is lifted by a pump to the degasser and any entrained gas is vented off. The degassed mud is then fed into the desander suction pit. The desander pump feeds the mud from this pit to the desander. The mud may also be fed directly from the sand trap to the desander pump which lifts the mud to the desander. The overflow mud from the desander falls to the desilter suction pit and the underflow is washed into the fine cuttings catch tank where it is mixed with fluid from the mineral oil wash tank, then centrifuged, and, finally the solids dumped into the ocean via the shale chute while the liquid is returned to the mineral oil wash tank.

Mud from the desilter suction pit is lifted by desilter pump to the desilter mud cleaner for further separation, the cleaned mud going to the active mud tank while the fine impurities pass to the fine cuttings catch tank. The mud from the active mud tank is centrifuged to remove fines before passing to the active mud transfer tank and from there to the mud circulation system. The fines are flushed into the shale chute for dumping into the ocean. The degasser pump may also be used for recirculating part of the mud from the active mud tank to the degasser.

If oil-based mud is used, then the cuttings from the shale shaker are fed through a gravity header into a coarse cuttings wash tank. The washed cuttings pass to the fine mesh classifiers and are flushed into the shale chute for dumping in the ocean. The finer solids passing through the mesh screens are transported to the fines wash tank for washing with fluid from the mineral oil wash tank.

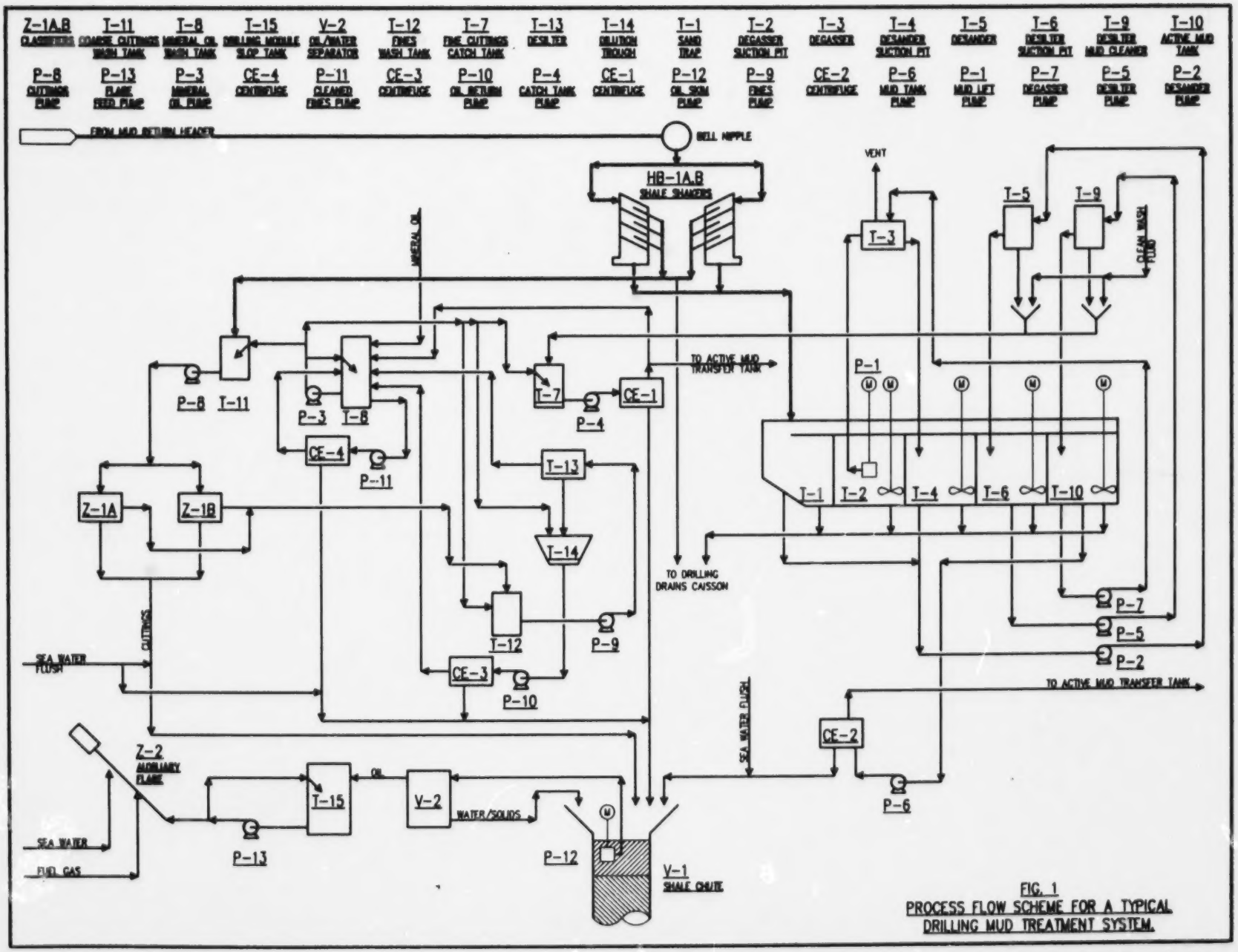

FIG. 1
PROCESS FLOW SCHEME FOR A TYPICAL DRILLING MUD TREATMENT SYSTEM.

The fines together with the liquid from the fines wash tank are transferred to a desilter. The overflow from this desilter returns to the mineral oil wash tank and the cuttings pass via dilution trough and centrifuge to the shale chute for dumping into the ocean while the liquid, containing some of the fines, is fed back to the mineral oil wash tank.

The cleaned fines from the mineral oil wash tank pass to the centrifuge for final separation. Reclaimed oil from this stage is returned to the mineral oil wash tank and waste product is flushed with sea water and dumped into the ocean via the shale chute. The oily water accumulated at the top of the shale chute is skimmed and fed to the oil/water separator. The waste oil from this separator is passed to the drilling module slop tank for burning in the auxiliary flare.

The auxiliary flare consists of flare boom and burner assemblies. The auxiliary flare should be supplied with sea water to provide the burners with a water shield in order to reduce radiation level and a fuel gas supply to provide atomizing gas for liquid burning. Any mud to be burnt should be mixed with diesel oil in the mud burn holding tank prior to injection into the burner nozzles in order to enhance the combustion process.

PLATFORM DRAINS

The platform drains embracing drilling area and production platform comprise independent systems; for example, (i) open drains; (ii) closed drains; (iii) drilling area drains; (iv) cement drain; and (v) jet wash water drain.

The open drains collect and dispose of hazardous and non-hazardous effluents. These include storm water from all areas except the drilling rig and adjacent modules subject to mud or cement spillage. The system collects oil-free water (fresh, cooling medium or sea water), diesel, glycol, chemicals (except methanol), etc. The open drains are generally collected in two separate headers for hazardous and non-hazardous areas respectively and finally fed into an open drains caisson. Wellhead, wellbay, separation and compression areas are generally designated as hazardous; utilities and power generation areas are designated as nonhazardous. The headers are terminated in the caisson below the lowest oil water interface level (LIL) and well below the lowest astronomical tide (LAT) level. The liquid seal thus provided prevents vapour backflow. Also, the oil layer is least disturbed because of the effluent joining below LIL. Liquid hydrocarbons separate out in the caisson and are pumped to the platform slop oil tank. Fig. 2 shows the process flow scheme for a typical drains and caissons system.

Pressurized closed drains from the production deck area (e.g. separation, gas compression, etc.) equipment, deaerator, various relief headers, etc., are generally passed to the flare knock-out drum via closed drains header. The vapour passes directly to flare and the liquid flows by gravity to the platform slop oil tank. For low pressure systems, e.g., during plant outages and equipment operating at low

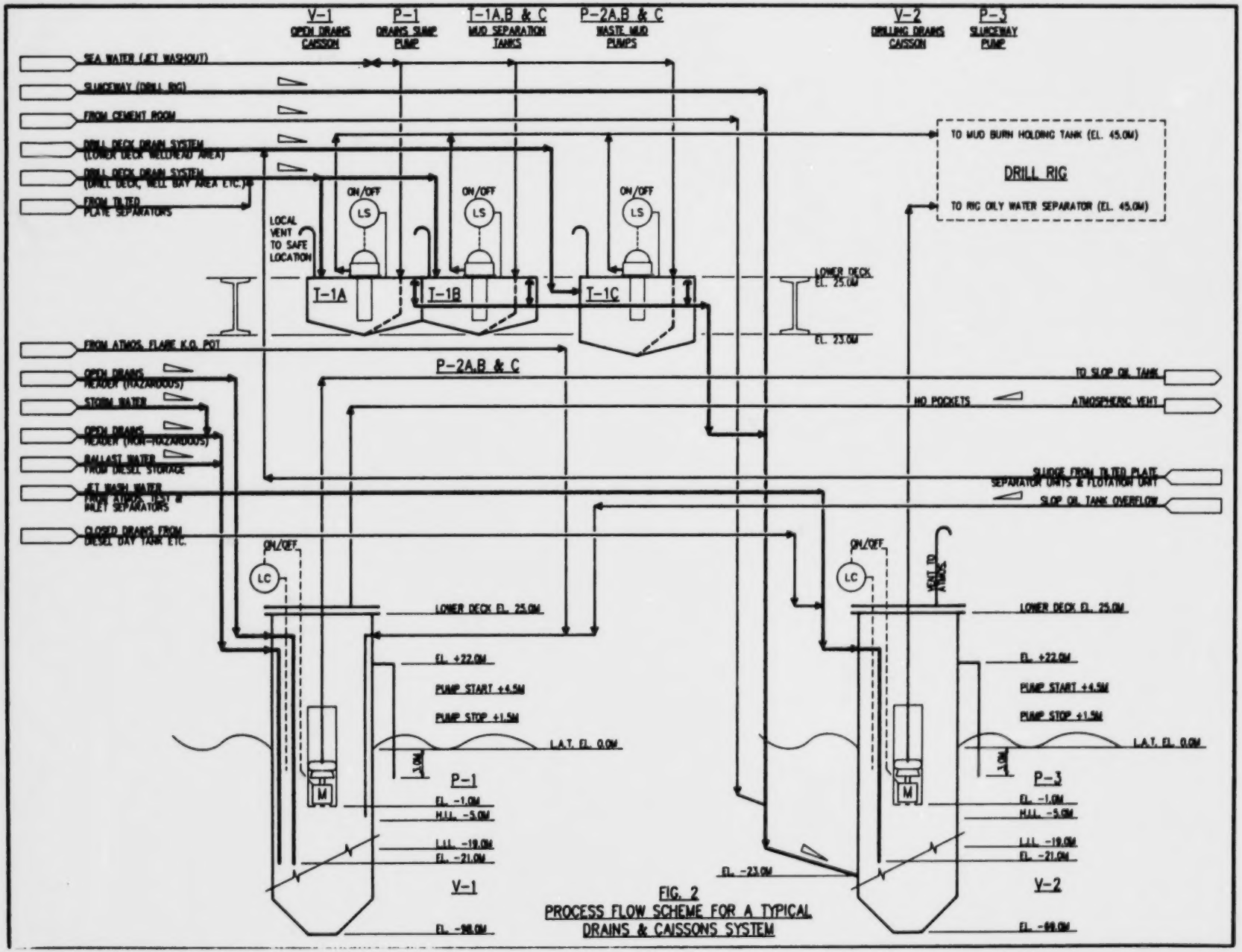

FIG. 2
PROCESS FLOW SCHEME FOR A TYPICAL DRAINS & CAISSONS SYSTEM

pressure, additional closed drains are routed direct to the platform slop oil tank. The overflow from this tank flows by gravity to the open drains caisson. The slop oil tank is level controlled by submerged slop oil pump(s) which is activated by an on/off level control switch discharging the oil to the low pressure separator. Ballast water from diesel storage is disposed of in the open drains caisson.

Storm water from all drilling areas where mud or cement spillage can occur is combined with drilling rig equipment drains and is fed to the mud separation tank. This tank consists of multiple compartments to facilitate clean-out of any section to proceed without interrupting drilling operations. Mud separates by gravity and is pumped to a mud burn holding tank before disposal in the auxiliary flare. Oily water overflows from the mud burn holding tank and passes through the drilling area sluiceway to a drilling drains caisson. The sluiceway also receives cuttings from the drilling operations and joins the drilling drains caisson more than 20 m below the LAT.

The cement drain from the cement room is separate from all others and discharges directly into the ocean via the drilling drains caisson.

Decks are washed down with a high pressure water jet and solvent degreaser. Also, some of the vessels are washed with high pressure water jet. The jet wash water drain collects effluent from these operations and drains into the drilling drains caisson.

PRODUCED WATER

Produced water associated with the crude and separated on the platform is treated to reduce solids and oil content below the regulatory requirement before being discharged into the ocean. Several methods of treatment are used in various parts of the world according to the nature of the water and the prevailing regulations. A Canadian Offshore regulation(1) requires a monthly average oil content of 40 mg/litre in the discharge to the ocean.

It is possible to achieve oil content of about 10 mg/litre in the effluent discharge with some of the existing industrial systems. It is normal practice to de-gas the produced water and treat it through an oil-water interceptor followed by an API-type oil/water separator or a flotation cell. With an API separator alone, one can achieve minimum oil content of about 50 mg/litre. It also requires a lot of space because of large surface area requirement. Conventionally, the produced water is first processed by corrugated plate interceptors or tilted plate separators and finally by an induced gas flotation unit to obtain better effluent quality. These interceptors on their own remove water droplets larger than 20 μ and are generally capable of reducing the oil content in water to 15-25 mg/litre level. In some of the recent designs, produced water coalescers are preferred over the tilted plate separators.

The corrugated plates are quite often spaced 1/4-1 inch apart depending on the sludge content. The gap may be larger for very high solids content. Fig.3 shows the process flow scheme for a typical offshore oily water treatment unit. The separators/interceptors separate oil and solids from the water by density difference. The solids settle at the sloped bottom from where they are removed when necessary by sea water (jet washout). The oil goes to the slop oil tank and the water-oil emulsion to the flotation unit.

Heating arrangement should be provided inside the slop oil tank to prevent freezing in the cold ocean environment. Fuel gas is induced into the flotation unit by internal dispersers. De-emulsifying chemicals are also injected into this unit which causes the small oil droplets to coalesce to form larger droplets. These oil droplets separate from the water and float on the surface as froth. The flotation unit separates the two phases, the oil going to the slop oil tank and the water discharged into the ocean.

Recently, liquid-liquid hydro-cyclones have been developed for treating oily water. It claims to reduce oil content in produced water to less than 30 mg/litre. This system is of precise geometry, light weight and compact and it is doubtful whether it can effectively treat feeds containing solids. However, it may be worthwhile to investigate the possibility of employing a liquid-solid hydro-cyclone followed by a liquid-liquid hydro-cyclone.

If oil content must be reduced to less than 5 mg/litre, then secondary treatment is necessary. For this purpose granular media (<5 mg/litre), coalescers (<5 mg/litre), or membranes (<2 mg/litre) can be employed. Some of these methods, although costly, may be considered on a floating platform to minimize the effect of vessel motion.

SEWAGE DISPOSAL

The sewage system collects all the sewage effluent from living quarters and treats them prior to dumping into the ocean. The treatment reduces the solids content and disinfects by reducing the biological oxygen demand (BOD), thus aiding in the quick assimilation of the disposed waste by the receiving sea water.

Regulations controlling effluent discharge vary according to the discharge location. Canadian offshore regulatory standards(2) stipulate for example, a coliform bacteria count not greater than 400/100 ml; suspended solids not greater then 75 mg/l; and BOD 50 mg/litre. Other standards require residual chlorine content in the effluent of not less than 0.5 mg/litre or more than 1.0 mg/litre after the chlorine has been in contact with the sewage for not less than 30 minutes. Standards can be more stringent for inshore lakes.

Fig. 4 shows the process flow scheme for a typical offshore sewage treatment system. The sewage effluent from the platform can be divided into two categories depending on the source.

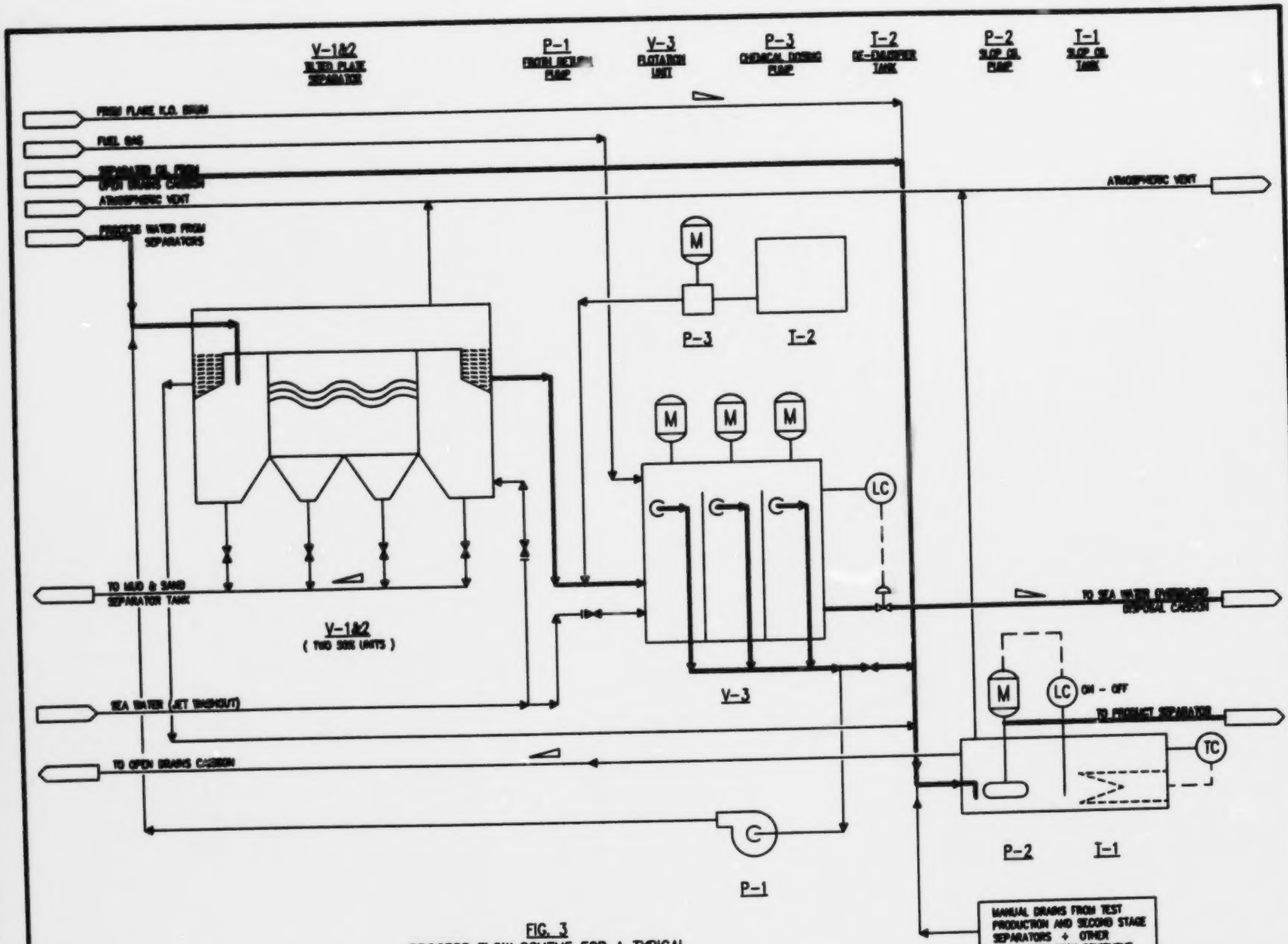

FIG. 3
PROCESS FLOW SCHEME FOR A TYPICAL
OFFSHORE OILY WATER TREATMENT UNIT

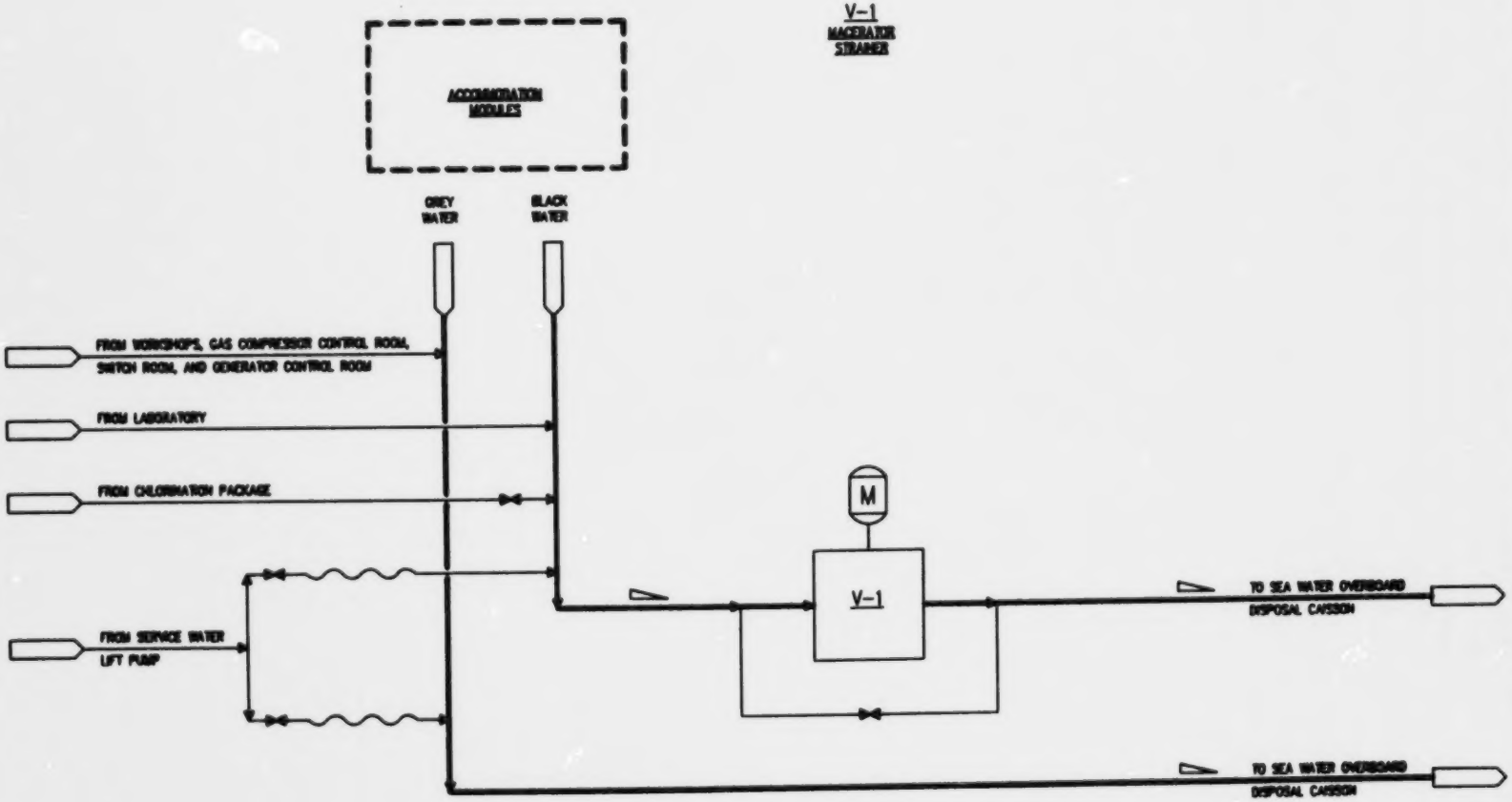

FIG. 4
PROCESS FLOW SCHEME FOR A TYPICAL
SEWAGE TREATMENT SYSTEM

'GREY' WATER - This effluent contains no raw sewage or gross solid matter and can be considered as dirty potable water. Source streams are from showers, laundry rooms, hand basins, and floor gulleys.

'BLACK' WATER - This effluent is foul and mainly sea water used to flush lavatories. Source streams are from lavatories, waste disposal units, and grease traps.

Grey water is collected and piped directly to the sea water overboard disposal caisson which goes to a depth of about 15 m below LAT.

Several types of packaged units for treating Black water are available from various manufacturers. A simple but effective method is to run this sewage through a macerator-strainer. The macerator strainer consists of an electrically driven macerator preceded by an inverted bar screen. The set angle of the screen together with the natural turbulence of flow in the chamber help develop a wash-down action which stops blinding of the screen.

This screen allows the water and particles smaller then 1/4" to pass through the system. Generally, the cutting element in the macerator consists of a fixed cutter located on the periphery of a high speed rotating impeller. A lot of turbulence is created during the operation of the macerator which helps to wash the screen. The design of the macerator also caters for self-protection from indestructible solids. The macerator may be programmed for varying operating periods, e.g. at intervals of 15 minutes in order to break up the large solid particles retained by the screen. The sewage treatment plant is sized on the basis of effluent of about 40 gal/day per person. Tanks, piping etc. coming into contact with the sewage are quite often plastic coated in order to avoid possible corrosion.

Chlorinated sea water is introduced into the Black water line intermittently upstream of macerator-strainer. Chlorine (in the form of NaOCl) is kept at 30-40 ppm level. During maintenance period Black water bypasses the macerator unit and flows directly into the sea.

Quite often air is bubbled through the sewage to promote aerobic digestion of the organic material. Microbial enzymes may also be added to further activate the biological process. Sewage hold-up time in the contact chamber is in the 15-20 hour range. After completion of treatment, the Black water is dumped into the ocean through the sea water overboard disposal caisson.

CONCLUSION

A comprehensive review of the wastes disposal problem on offshore oil and gas platform has been made. The treatment schemes are very much influenced by the source and composition of wastes. The various sources have been identified and suitable treatment schemes proposed with particular emphasis on the Canadian offshore scene.

ACKNOWLEDGEMENT

The author wishes to thank Stone & Webster Canada Limited for support and encouragement in publishing this paper.

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INCINERATION AT SEA

John Karau
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Environment Canada

CANADIAN POLICY

In Canada ocean incineration is regulated by Environment Canada under the national Ocean Dumping Control Act (ODCA) and the international London Dumping Convention (LDC). Both the ODCA and the LDC obligate Canada to take effective measures to prevent marine pollution by dumping and to promote the control of all sources of marine pollution.

Less than 1% of total industry production in Canada becomes waste and only about 10% of this (approximately 3 million tonnes per year) is considered hazardous. Hazardous products such as PCBs, insecticides and herbicides, that have been banned or phased out, also require special treatment and disposal. Within the limits of its authority, Environment Canada is committed to fully exploring all environmentally sound options for managing hazardous wastes. Available evidence shows that incineration at sea is one of many options which, if properly controlled, could help in the management of hazardous wastes.

Environment Canada is prepared to consider issuing an ocean dumping permit for incineration at sea if an applicant can meet the regulatory requirements (LDC regulations and ODCA permit conditions) and there are no practical alternatives that are environmentally preferable. This policy reflects the premise that the incineration of PCBs and other similar hazardous wastes using acceptable destruction methods is of lower environmental risk than their continued storage. As quantities of hazardous wastes in storage increase, so does the potential for human and environmental exposures to fugitive emissions and accidental spills, and for damage due to fire or explosions.

STATUS OF INCINERATION AT SEA

Canada has not incinerated chemical wastes using ocean incineration vessels and has no immediate plans to do so. We have received a preliminary application from Chemical Waste Management, Inc., owners of the commercially available ships Vulcanus I and II. We have also met with representatives from Seaburn Inc. to review their container-based incineration system which is considered to be a promising technology. Our priority at this stage is to prepare an operating procedures manual for incineration at sea destruction facilities.

We are also aware that despite numerous evaluations of incineration at sea over the past 15 years of operating experience, conflicting opinions still exist. Concerns regarding incineration at sea range from questions relating to the effectiveness and safety of marine incineration to opposition in principle based on the view that it is merely an inexpensive option which detracts from pollution control at the source. This type of controversy does not do much to build public confidence that the practice is safe and could help in the management of hazardous wastes.

In the United States 51,300 tonnes of hazardous waste were incinerated at sea between 1974 and 1982. In 1984 the Environmental Protection Agency (EPA) decided to defer issuing further permits until specific regulations (under the Marine Protection, Research and Sanctuaries Act) were developed and additional research was undertaken. The draft regulations are still being developed and additional test burns to evaluate incinerator performance and environmental effects are propose to take place once the regulations are finalized. Recently, the EPA has completed two major reviews on incineration at sea as a waste management option:

1) Assessment of Incineration as a Treatment Method for Liquid Organic Hazardous Wastes, and

2) Report on the Incineration of Hazardous Wastes.

The basic conclusions from these assessments were as follows:

- Incineration, whether at sea or on land, is a valuable and environmentally sound treatment option for destroying many liquid organic hazardous wastes.

- In terms of health and environmental risks, there is no clear preference between ocean and land based incineration.

- The demand for waste incineration is likely to exceed current capacity as land disposal alternatives for wastes are increasingly restricted under new regulations. New alternative methods for incineration are unlikely to provide major capacity increases in the near future.

- Although research has verified the destructive capabilities of incinerators and risk studies have suggested that their impacts on health and the environment are minimal, a program of continuing research is needed to improve current knowledge of combustion processes and effects.

- The concerns of citizens regarding incineration need to be better addressed.

In Europe 1,324,00 tonnes of hazardous waste have been incinerated at sea since 1969. The Oslo Commission, which covers incineration at sea in European waters, has initiated a review of this practice with the intention of establishing, by January 1, 1990, a date when (if at all) ocean incineration should be terminated. Opponents of ocean incineration in Europe have expressed the view that it is a temporary disposal method and should not be used where practical alternative methods of land-based treatment and disposal exist. Supporters for incineration at sea feel that the need for hazardous waste destruction maintains the demand for marine incineration and that sensible use of all environmentally acceptable methods will contribute best to hazardous waste management.

The London Dumping Convention (LDC) plans to convene a group of experts in cooperation with the Oslo Commission to examine conflicting accounts of the effectiveness and safety of marine incineration of organohalogens, both per se and in relation to land-based disposal alternatives. The Tenth LDC Consultative Meeting of October 13-17, 1986, will be asked to adopt terms of reference for a meeting of experts to review those scientific and technical matters required to:

1. provide the Consultative Meeting with the scientific and technical information required to enable it to review and assess marine incineration as a disposal option; and

2. provide advice on the management and control of marine incineration, including any appropriate revision of the present mandatory regulations and technical guidelines.

The Netherlands proposes to conduct a test burn of PCBs in the fall to help address the scientific and technical questions relating to the effectiveness and safety of marine incineration of organohalogen wastes.

ODCA INCINERATION PERMITTING PROCEDURES

Environment Canada has examined the available information and has found no data to indicate that incineration at sea is an unfavourable method of waste disposal. Some scientific questions do remain (e.g., what new organic compounds may be synthesized during the incineration process); however, they are not considered to be of such a magnitude or nature as to modify the policy support for incineration at sea as a viable technology. At the same time we recognize that public support is essential if incineration at sea is to go forward.

In evaluating specific proposals for incineration at sea, Environment Canada will be following the application review procedures outlined in Figure 1 (Ocean Incineration Permitting Procedures).

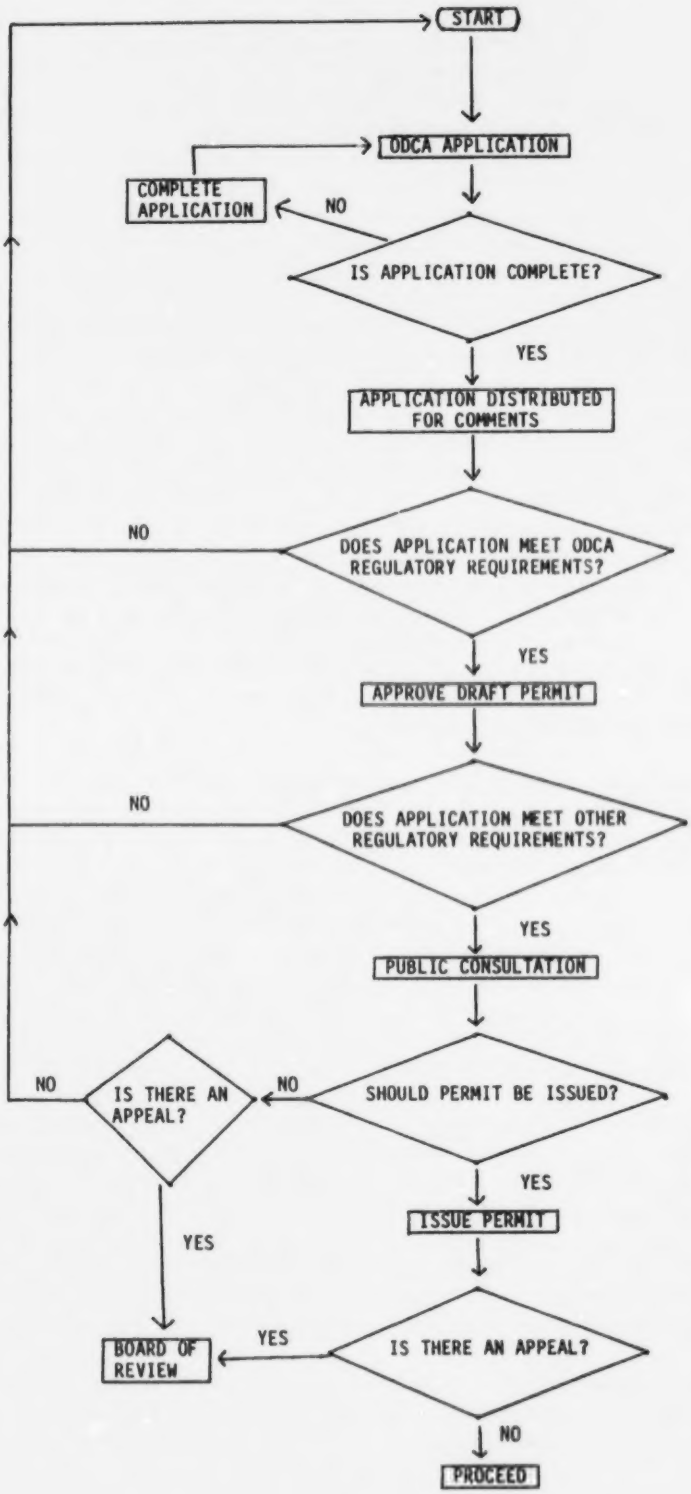

FIGURE 1 OCEAN INCINERATION PERMITTING PROCEDURES

For an application to be considered complete, descriptions must be provided for the following elements:

- waste transportation, handling and storage;
- equipment operation and maintenance;
- waste analysis and test methods;
- monitoring and record keeping;
- cleaning operations;
- contingency plans;
- liability insurance; and
- reason for incineration at sea compared to other options.

Completed applications will be distributed to other involved and interested parties, such as the Canadian coast and provincial environmental agencies, for their comments.

The ODCA permit requirements parallel the LDC regulations and include provisions for site specific requirements. The LDC regulations which Canada helped to draft are considered to provide an effective level of control and protection. Specific standards exist for:

- vessel certification (e.g., IMO Type II Bulk Chemical Carrier);
- wastes requiring special studies (e.g., PCBs);
- performance (Destruction and Combustion Efficiency);
- recording devices and records;
- transportation and storage;
- contingency plans; and
- cleaning operations.

For practical reasons, Environment Canada will draw heavily on data from LDC certifications and pilot scale tests for its technical review of any applications. The small quantities of Canadian liquid waste suitable for incineration at sea make it very difficult to present a Canadian test burn as a non-operational burn. This does not exclude the possibility that Environment Canada may require additional test data before permitting incineration at sea.

Ocean incineration would be deemed acceptable and a draft permit prepared if the ODCA reglatory requirements could be met and if it posed less or no greater human health and environmental risks than practicable land-based alternatives.

Canada would require an ODCA loading permit and an LDC dumping permit, or similar approval, before allowing export of hazardous wastes for incineration at sea. In addition, if the dump site were under the national jurisdiction of a third party country that objected to the planned dumping operation Canada would not issue an ODCA loading permit.

No permit for incineration at sea would be granted if the operation were prohibited under any other act of parliament or if a licence or permit required under any other such Act has not been obtained. This contributes to a comprehensive waste management approach. Applicants are specifically informed that they require provincial approval for the land-based collection, transportation and storage of waste. Transportation of wastes also involves the federal Transportation of Dangerous Goods Act.

To help ensure that the ODCA permit process complies with Environment Canada's "Public Consultation Policy", we are prepared to work with an applicant and the involved provinces in the development of public information and consultation programs. The following waste management operating principles will be taken into account whenever the sea disposal option is considered:

1. Whenever possible, recycle and reuse waste products.

2. Wastes that cannot be recycled or reused should be treated at the source to the extent possible.

3. Wastes that cannot be avoided or reused at a reasonable cost must be disposed of safely.

4. Sea disposal should only be used if it poses less or no greater human health and environmental risks than practicable land-based alternatives.

All ocean dumping permits and amendments to permits must be published in the Canada Gazette before they can be implemented. If a permit is refused, or if the applicant is dissatisfied with the operating conditions specified therein, he may appeal and call for a Board of Review. A Board may also be established to hear objections from the general public to the granting of any permit, or the terms under which it is issued.

Inspections are conducted to verify compliance with the terms of a permit. Inspectors appointed under the ODCA may seize or detain any ship suspected of violating any provision of the Act or regulations, including the terms and conditions of a permit. If the owner is convicted, the vessel may be forfeited. Besides having to pay a fine of up to $100,000 for each offence, he may be billed the cost of any clean-up operation or other remedial action taken by the Crown.

SUMMARY

In summary, the ODCA permit system and the LDC regulations are considered to provide an effective level of control and protection to permit incineration at sea.

The disposal of hazardous wastes is considered preferable to continue land storage and there is no clear preference between incineration at sea or on land in terms of health and environmental risks.

Finally, the increasing need for waste destruction compared to the availability of land options maintains the demand for incineration at sea.

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THE PROBLEMS OF OCEAN INCINERATION: A CASE OF MODERN MYTHOLOGY

by

George P. Nassos

Chemical Waste Management, Inc.

PROLOGUE

The ocean incineration industry originated in 1969 when the dumping of certain hazardous wastes in the North Sea became prohibited. Through an international conference, Europe regulated the disposal of highly chlorinated waste by requiring it to be incinerated, but the scrubber technology was not sufficiently advanced to incinerate the hazardous waste on land. Thus ocean incineration technology had its birth.

In 1972 Ocean Combustion Service BV, Rotterdam, The Netherlands, converted a dry cargo vessel to an incineration ship named the VULCANUS. During the next eight years, this vessel operated primarily in the North Sea but also incinerated U.S. waste in the Gulf of Mexico and the Pacific in 1974 and 1977. The United States Environmental Protection Agency was impressed by this technology and encouraged that it be brought to the United States.

In 1980 Chemical Waste Management, Inc. (CWM), a wholly owned subsidiary of Waste Management, Inc., acquired Ocean Combustion Service and the VULCANUS vessel with the intent of providing ocean incineration to U.S. generators while continuing to service the European market. The company immediately applied for permits to operate the ship in U.S. waters. VULCANUS continued to operate in Europe under the new ownership but returned to the U.S. in December, 1981 and and again in August, 1982 and incinerated two shiploads of PCB waste in order to demonstrate the effectiveness and safety of the process. In anticipation of receiving a U.S. permit, Chemical Waste Management built a new ship the VULCANUS II (Figure 1), and launched it in November, 1982 in Europe where it has since been operating.* In 1983, the VULCANUS was retrofitted to bring it to the state-of-the-art and renamed VULCANUS I. CWM's plans are to operate VULCANUS I in Europe and VULCANUS II in North America.

While the U.S. PCB research burns were successful and the U.S. EPA stated that no other research was necessary to prove the technology, in May, 1984 it reversed its tentative decision of November, 1983 by denying CWM research or operating permits. EPA's decision was based on the need to obtain more information before proceeding with the program. Specifically, EPA requested a market and risk assessment of land-based and ocean incineration (published March, 1985), specific ocean incineration regulations (proposed in April, 1985 but not yet final), and the development and implementation of a research plan to answer the questions raised by Congress, environmental groups, and the public community.

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*In addition to VULCANUS I and VULCANUS II, the German owned VESTA is the only other ocean incineration vessel operating today.

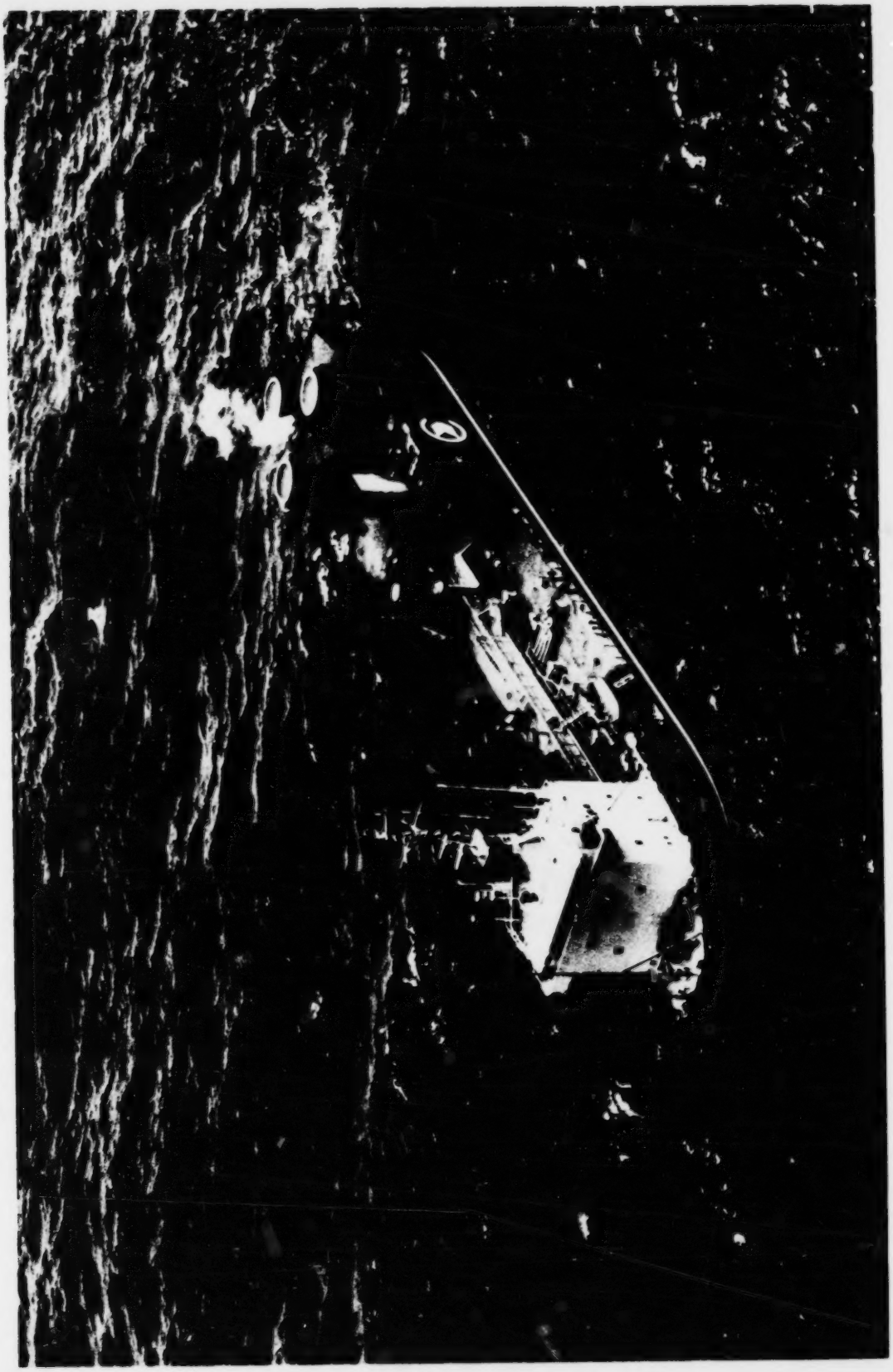

Figure 1 - VULCANUS II

In September, 1985 CWM submitted a permit application to conduct this proposed research. EPA made a tentative determination in December, 1985 to issue the research permit, however, CWM is again experiencing delays in the permitting process.

At this point one must raise the question why, after five years of seeking approval to operate this technology in the U.S., a positive conclusion is still not imminent. While there are several contributing factors to this dilemma, the single biggest is the opposition from some local and national environmental groups, a small number of local but vocal citizens, and a small number of politicians. Their opposition stems primarily from a number of misconceptions concerning the effectiveness, need and safety of ocean incineration and is the subject of this paper, "The Problems of Ocean Incineration: A Case of Modern Mythology".

MYTH #1: "THERE IS NO NEED FOR OCEAN INCINERATION CAPACITY"

Numerous ocean incineration opponents contend that there is no need for additional incineration capacity, let alone incineration-at-sea capacity. However, a review of the expected supply and demand during the next few years reveals that there will be a severe shortage. This can be demonstrated by looking at just two segments of the liquid organic hazardous waste (LOHW) market.

One segment of the LOHW market which is of major concern to the U.S. public is that of PCB liquids. As seen in Table 1, the total inventory of PCB liquids that will require disposal is about 150 million(MM) gallons. This number was estimated from a 1981 inventory determination of the electric utility industry[1] and subtracting from it an estimate of the quantity that has already been disposed of.

Table 1

DEMAND FOR PCB LIQUID DISPOSAL

	Currrent Inventory (MM gal.)	Capacity Needed (MM gal./yr.) for Disposal in 5 yrs.	7 yrs.
Askarels + flushate	40		
Mineral Oil -- 50 ppm	110		
Total Required for Disposal	150	30	21
Mineral Oil -- 5-50 ppm	240		
" " -- 2-5 ppm	160		
Potential Total Required for Disposal	550	110	80

While the current EPA regulations pertain only to PCB liquids of concentrations at 50 ppm or greater, there has been some pressure to lower the regulated level to 5 ppm or even 2 ppm. These pressures are the result of the increasing concern of liability due to exposure of PCB's even at low concentrations. Based on the same inventory analysis an additional 400 million gallons may be required for disposal if the regulations are modified to include PCB liquids as low as 2 ppm.

It is important to note that these numbers pertain only to the PCB liquids contained in electrical transformers from both the utility and non-utility sectors. Other liquid sources, such as solvents, fuel oils, and ponds that may have been accidentally contaminated with PCB's have not been included. It is very difficult, if not impossible, to estimate this volume of PCB contaminated liquids.

The demand must now be compared with the current available capacity for the disposal of PCB liquids. There are only three large and one small commercial incinerators with a total current operating rate of about 14 million gallons per year. In addition, the chemical dechlorination processes presently treat about eight million gallons per year of PCB oils less than 2,000 ppm. The permitting of ocean incineration in the U.S. could add about 12 million gallons per year from the VULCANUS II and another 18 million gallons per year from the APOLLO I.*

A comparison of the supply and demand shows that the current incineration capacity is adequate for only one scenario. It assumes that only the currently regulated PCB's from electrical transformers would require disposal and completion over a period of seven years or more would be environmentally acceptable. Further, it assumes that PCBs less than 50 ppm would not become regulated and that the quantity of other PCB contaminated liquids is insignificant. This scenario is unlikely at best.

A second segment of the LOHW market is that of the organics that will require incineration as a result of the land disposal bans. It is estimated that the ban of liquid organics from commercial landfills requiring incineration is about 25 million gallons per year.

EPA has also looked at the potential impact of banning organics from liquid injection wells, a regulation which will not go into effect until late 1988 due to the unavailability of alternate disposal capacity. EPA's estimate assumes that 50% of the current waste being injected in deep wells will be affected by this ban. Of this quantity, 5% may be

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*This ship was built by Tacoma Boat Co. and to be operated by its subsidiary, At-Sea-Incineration, Inc. Tacoma Boat filed bankruptcy in late 1985 and the Maritime Administration was forced to pay the loans which it had guaranteed. The future of this vessel, constrained by court proceedings, will also be dependent on the permitting of VULCANUS II.

incinerated directly while an additional 30% will require treatment and be reduced to a volume such that 5% would be subsequently incinerated, resulting in a total of 6.5% of the affected quantity going to incineration. Applying these assumptions to a volume of 11.5 billion gallons per year[2] results in a potential of 375 million gallons requiring incineration after 1988.

The current commercial capacity for non-PCB liquid incineration is about 55 million gallons per year. A conservative estimate of the utilization rate of these incinerators is 50%, which when added to another 15 million gallons per year of new capacity expected to come on-stream in the next two years, results in a total of about 43 million gallons of available capacity--far short of the 400 million gallons per year of expected new demand.

Based on just these two segments of the LOHW market, it can readily be seen that there is a significant need for additional incineration capacity in the U.S., both on land and at sea. The capacity shortfall is even greater if one were to include the land disposal bans on surface impoundments and on-site landfills, new regulations pertaining to hazardous waste fuel and waste oil, and the numerous pending clean-ups.

MYTH #2: "OCEAN INCINERATION, BEING A CHEAP DISPOSAL OPTION, WILL DISCOURAGE WASTE REDUCTION, RECYCLING AND ENERGY RECOVERY"

Although the actual cost of operating an ocean incineration vessel will not be known until the specific ocean incineration regulations are published, it is unlikely that it will be considered cheap relative to land-based options. The proposed regulations will require each manifested waste stream to be sampled and analyzed for the restricted and prohibited substances to be sure the waste meets the permit requirements. This type of analysis, which is not a requirement of land-based incinerators, will cost about $3,000 per sample. The proposed regulations will also require liability insurance in the range of $50 to $500 million dollars, the pre-miums of which would be very expensive if the insurance is even available. It is truly a misconception to believe that ocean incineration will be a "cheap" disposal option.

One recent analysis of five thermal destruction options compared the discounted cash flow rate of return (DCFRR) of: 1) a rotary kiln, 2) fluidized bed incineration, 3) liquid injection incineration, 4) plasma arc pyrolysis, and (5) ocean incineration; and showed that the ocean incineration option was the least economical[3]. The DCFRR for the four land-based options ranged from 29% to 39% while that of ocean incineration was calculated to be only 17%. Details of this analysis are unavailable, however, preliminary indication confirms that ocean incineration is not a "cheap" disposal option.

With respect to ocean incineration discouraging waste reduction, the disciples of this myth fail to recognize an EPA regulation concerning minimization of waste generation. Every generator shipping hazardous waste for disposal must attest on the manifest that the generator has

implemented a waste minimization program.

There has also been concern that incinerating liquid organic hazardous waste at sea will preclude the option of any energy recovery. Associated with this concern is that some land-based incinerators fear that high-level BTU waste will not be available for the destruction of low BTU solids. In general, the liquid organic waste most suited for incineration at sea is the highly chlorinated waste streams that tend to be low in BTU value.* The one exception is PCB-contaminated mineral oil, which has a relatively high BTU value; however, it is a short-term market, as described earlier.

MYTH #3: "OCEAN INCINERATION IS AN INTERIM PROCESS AND WILL BE TERMINATED IN EUROPE"

This may not exactly be a myth since all processes can be considered interim until other more effective and/or economic ones are developed.

Ocean incineration was designed to serve a specific need and was not considered interim until the Oslo Convention (1976) set a date of January 1, 1990 as to when a decision would be made on the ultimate fate of ocean incineration. While there are some pressures in Europe to terminate ocean incineration there is also considerable support for the technology. For example, CEFIC** endorses ocean incineration and has recently stated, "Experience of incineration at sea as a method of hazardous waste destruction has left no doubt that this method is environmentally acceptable, safe to handle, and cost effective".[4]

There are major efforts in Europe to terminate ocean dumping. Ocean incineration is not ocean dumping, and it is unfortunate that this effective destruction technology is associated with dumping.

MYTH #4: "OCEAN INCINERATION IS NOT AN EFFECTIVE PROCESS FOR DESTRUCTING HAZARDOUS WASTE."

It is amazing that this misconception has developed considering that the VULCANUS I and VULCANUS II vessels are probably the most thoroughly tested hazardous waste incinerators in history. Table 2 lists some of the results from the testing of Vulcanus I during the past 12 years.[5] The destruction efficiencies (a measure of waste destroyed divided by waste input expressed in percent) exceeded the EPA minimum requirement of 99.99% for waste other than PCB's which have a minimum requirement of 99.9999%. The "greater than" sign shown in Table 2 means that the

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*The VULCANUS II has proven to destroy effectively waste with a heat value as low as 500 BTU/lb.

**The European Federation of Chemical Industries comparable to the Chemical Manufacturers Association in the U.S.

species of interest were not detected at all and the destruction efficiency exceeded the analytical detection limit of the monitoring equipment. In the Herbicide Orange burn none of the species analyzed was detected in the samples. Again in the second PCB research burn, all of the calculated destruction efficiencies were greater than 99.99% indicating that no PCB's or chlorobenzenes were found in these samples.

Table 2

VULCANUS I TEST RESULTS

Date	Compound	Average Destruction Efficiency (%)
11/74	Bis(dichloromethyl) ether	>99.99998
(Shell)	Tetrachloroethane	>99.99994
	2-Chloroethyl formate	>99.9997
	1,1,2-Trichloroethane	99.997
	1,2,3,4,-Tetrachlorobutane	>99.99992
	1,2,3-Trichloropropane	>99.992
	2,3-Dichloro-1-propanol	99.996
	1,1-Dichloroethane	>99.99992
	1,2-Dichloroethane	>99.99998
	Dichloropropene	>99.99997
	1,2-Dichloropropane	99.9995
8/77	2,4-D	>99.999
(Herbicide	2,4,5-T	>99.999
Orange)	TCDD	>99.93
8/82	PCB w/ 1 Chlorine Atom	>99.997
(PCB's)	PCB w/ 2 Chlorine Atoms	>99.9993
	" " 3 " "	>99.9997
	" " 4 " "	>99.9998
	" " 5 " "	>99.99999
	" " 6 " "	>99.99992
	" " 7 " "	>99.99993
	" " 8 " "	>99.99994
	Chlorobenzenes	
	w/ 1 Chlorine Atom	>99.9989
	w/ 2 Chlorine Atoms	>99.9994
	" 3 " "	>99.99996
	" 4 " "	>99.99994
	" 5 " "	>99.9999
	" 6 " "	>99.99992

The testing of VULCANUS II was conducted jointly by EPA and TRW, Inc. in 1983 utilizing a plan approved by the EPA. Using an incinerability index, which is defined as the relative ease to oxidize a constituent to the ultimate product of combustion, one can designate the principal organic hazardous constituents, better known as POHC's. The POHC's are selected to represent the constituents of waste which are least likely to be completely destroyed or combusted; thus, if difficult to destroy POHC's are incinerated satisfactorily the remaining constituents are

expected to be destroyed to at least the same or greater extent.

POHC's selected from the cargo used in the testing of the VULCANUS II are shown in Table 3 along with the results.[5] The lowest destruction efficiency was that of carbon tetrachloride with a value of 99.998%. In a hierarchy of POHC's carbon tetrachloride is listed as the fourth most difficult compound to destroy by high temperature incineration. Consequently, the VULCANUS II has proven to be capable of incinerating any organic compound with an incinerability index greater than that of carbon tetrachloride.

Table 3

VULCANUS II TEST RESULTS

Date	Compound	Average Destruction Efficiency (%)
2/83	1,1-Dichloroethane	99.99994
	1,2-Dichloroethane	99.99996
	1,1,2-Trichloroethane	>99.999995
	Chloroform	99.9996
	Carbon tetrachloride	99.998

Another concern that has been mentioned by scientists and the environmental community is the formation of other compounds during the combustion process. These compounds, known as products of incomplete combustion or PIC's, have not been analyzed to any great degree in the past and could perhaps also be toxic. EPA regulations, however, not only require a minimum destruction efficiency but also require incinerators to achieve a minimum combustion efficiency (a measure of the complete break-down of the waste into carbon dioxide and water) of at least 99.9%. This indicates that if any PIC's are formed their concentration is likely to be extremely small. Studies have also shown that even if the combustion efficiency falls slightly below its minimum required level, the destruction efficiency will remain above the prescribed limit.[6]

If one assumes that as the worst case the VULCANUS II achieves a destruction efficiency of exactly 99.9999%, the minimum required by EPA, to what degree would the incineration process be polluting the ocean with PCB's--another concern raised by many environmentalists. Assuming further that the VULCANUS II were to operate at a capacity of 52,500 metric tons (MT) per year, (3,500 MT per voyage times 15 voyages per year) and were incinerating a relatively high average concentration of 15% PCB's, the total annual deposit of PCB's in the ocean would be about 17 lbs. To put this in perspective, one must compare this release of 17 lbs. per year of PCB's via the VULCANUS II to the quantity being discharged annually from waste water treatment plants, major and minor industrial discharges, power plants, urban and nonurban nonpoint runoff and streamflow entering the coastal zone. In 1982 over 12,000 lbs. of PCB's from these sources were discharged into Chesapeake Bay alone.[7]

Some technical people have even shown concern with the effectiveness of

the incineration process being reduced because of the movement of the system on a pitching and rolling vessel. This misconception can be explained by reviewing the four critical factors which determine the effectiveness of the incineration of liquid wastes, namely: 1) atomization, 2) mixing, 3) temperature, and 4) residence time.

The major question has been whether rotary cup burners effectively atomize the liquid when subjected to a lateral or vertical movement. The rotary cup burners operate at a fixed speed of about 6,000 RPM. The waste is delivered through a central tube to nozzles near the periphery of the cup. The rotational velocity spreads the waste into a thin sheet as it forces the material to move to the rim of the cup where it is discharged from the rim as a thin continuous film. The film becomes unstable and breaks up into tiny droplets. High velocity combustion air is introduced through an annulus surrounding the rotary cup to assist in the disintegration of the thin film at the rim of the cup, to provide thorough mixing of the waste droplets with combustion air and to shape the flame. When one considers that the pitching and rolling of the ship may be at a frequency of about 6 RPM, the rotary cups are operating at speeds three orders of magnitude greater than that of the movement of the ship. If the ship movement were to cause anything but an insignificant effect on the performance of the rotary cups, some of the basic laws of physics will require editing.

Mixing in the incinerators is accomplished by the orientation of the three burners within each incinerator and the high velocity of air introduced through each of the burners. One burner is arranged to fire in a direction opposite the other two in order to prevent excessive swirl and at the same time promote turbulence. The turbulence is such that an excessively long stack of about 500 feet would be required before the flow would return to the laminar flow region. The air feed rate through each of the burners is about 18,000 CFM. Under these conditions it is difficult to understand how mixing could be affected in any way by the movement of the ship.

The most critical operating parameter in incineration is the temperature itself which obviously is not affected by the ship's movement. The incinerators operate at a wall temperature of about 1200°C and a flame temperature approximately 150°C higher. This is well above the temperature required to combust all organic waste accepted by the Vulcanus vessels. With an average residence time of about one second, which probably greatly exceeds the necessary residence time to achieve the minimum destruction efficiency, again no impact from the ship movement can be expected.

MYTH #5: "OCEAN INCINERATION WILL AFFECT HUMAN HEALTH AND THE ENVIRONMENT THROUGH A SPILL OR THROUGH STACK POLLUTION."

Actuarial data on the spill history of ocean incineration vessels is somewhat limited and thus a meaningful conclusion cannot be achieved. In a recent EPA report, however, a risk assessment calculated the frequency of all spills for the VULCANUS II to be 1 per 1,200 operating

years.[8] A spill involving three or more tanks would occur only once each 24,000 years.

EPA's report, however, estimated the expected volume of releases from the VULCANUS II, in a statistical sense, to be even less. This is due to the superior construction of the VULCANUS II over the typical chemical tanker and the additional safety restrictions to be imposed by the Coast Guard. The VULCANUS II is defined by the U.S. Coast Guard as a Type 2 vessel and is constructed with a double hull and double bottom with the cargo contained in eight separate tanks, each of these features incorporated to minimize the risk of a spill. The ship draws about 21 feet of water when fully loaded compared to the large chemical tankers which have a 37 to 40 foot draft. The VULCANUS II, as well as VULCANUS I, is also equipped with bow thrusters which aid significantly in its maneurverability. These bow thrusters are so effective that the ship can make a 180° turn within one ship-length steaming at a speed of 12 knots per hour. The Coast Guard has imposed restrictions such as travel only during daylight and in good weather with a minimum two-mile visibility. Also the ship will travel through an estuary under tug escort and a moving safety zone. As a result of these added safety features, E.P.A. estimated the risk of a spill to be only .001% of expected releases of ongoing shipments of hazardous substances in the Gulf area.

Equally significant to specific estimates of risk of spills are comparative statistics on bulk chemical shipments. In 1983, for example, 274 million MT of hazardous substances were transported in the Gulf of Mexico. By comparison, the total volume transported by VULCANUS II in a year's operation would be 0.02% or one five-thousandth of the total volume of hazardous substances alone. In other words, a greater volume of hazardous chemicals used in industry is shipped through Gulf Coast ports in just two hours than the VULCANUS II would carry in a whole year's routine operation.

In 1985 there were approximately 2,800 ship arrivals through the Delaware River. Despite this volume of traffic, there were only six incidents of which five were groundings and no collisions.

In addition to the above, claims of catastrophic effects from a spill must be weighed against the everyday occurrences ending just a decade ago. That was when the petro-chemical industry for some twenty years dumped millions of tons of liquid wastes including chlorinated hydrocarbons directly into the water off our nation's coasts.[9] In 1973 for example, 1.4 million MT of hazardous wastes were dumped directly into the Gulf. This is the equivalent of a full load of VULCANUS II dumped directly each day of an entire year. Such dumping was unacceptable and should never again be repeated. One may note, however, that marine life in the Gulf survived as did the fisheries and tourism industries dependent upon it.

Of significant importance also is the historical record of the VULCANUS I and VULCANUS II ships while operating in Europe, the Gulf of Mexico and in the Pacific. Since 1972 VULCANUS I has incinerated over 430,000 MT during 145 voyages, while the VULCANUS II during its 3½ years of

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A REGULATED COMMUNITY PERSPECTIVE

Paper unavailable at time of printing

WASTE MANAGEMENT INITIATIVES IN ONTARIO

R. M. Gotts
Director
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Ontario Ministry of the Environment

Thank you Mr. Chairman. Good morning ladies and gentlemen.

Thank you for the opportunity to address the 8th Canadian Waste Management Conference. Today, I would like to use my time to bring you up-to-date on what is happening in several major areas of waste management in Ontario.

BACKGROUND OF ONTARIO'S WASTE MANAGEMENT PROGRAMS

Before we go into recent initiatives in Ontario's waste management programs, I would like to summarize some of the past and existing waste management programs. It will also help you appreciate the reasons for changes.

The Environmental Protection Act (EPA) was first introduced in Ontario in 1971. Part V of the EPA provides the legislative authority for the various waste management regulations.

Prior to June, 1985, there were two major regulations. The Ontario Regulation 309 provides the general waste management requirements, such as definitions, various classifications and facility standards, while the Ontario Regulation 313 specifically deals with the waybills, a documentation for liquid industrial waste transfers. Ontario started to use the waybill system back in 1977; a pioneer move in Canada as well as in the U.S. Through improvements of the past eight years, we now have a fully computerized tracking system with a detailed follow-up program.

While we have achieved a lot in the past decade, our experience showed us that there were major areas of deficiencies.

In June, 1983, the Ministry launched the "Blueprint for Waste Management in Ontario", an all-encompassing discussion document which outlined proposals for a wide range of emerging issues. The Ministry held public meetings on this package with industry and the public from Cornwall to Kenora.

The first major initiative launched by the Ministry after the Blueprint process was the amendments to Regulation 309 in dealing with industrial waste management issues.

HAZARDOUS WASTE MANAGEMENT

On June 17, 1985, these amendments were made to Ontario Regulation 309. This is a result of several years of effort with extensive public consultation particularly through the Blueprint process which lasted for two years. This new regulation provides increased responsibilities for all three parties in the field of waste management: the generator, the carrier, and the receiver. The major revisions include:

(1) Comprehensive definitions for hazardous waste and liquid industrial wastes and other related definitions such as recyclable material, waste-derived fuel and dust suppressants.
- These definitions provide the foundation upon which the regulation has been built and that, when used in conjunction with new regulations and guidelines, provides industry with a clear target for compliance.

(2) Expanded manifest requirements to cover both solid hazardous wastes and liquid industrial waste.
- The manifest requirement is compatible with regulations under the federal Transportation of Dangerous Goods Act. In fact, the new Ontario manifest form is virtually identical to the form specified under federal transport regulations. In this way, one manifest will be used in Ontario to comply with federal and provincial environmental and transport regulations.

(3) Increased Waste Generator Responsibilities.
- The major responsibility requires generators to register their company and their wastes with the Ministry and in return receive company identification numbers and waste class numbers.
- Increased responsibilities will also require generators to identify the intended waste receiver on each manifest, and to follow-up to ensure each waste load has been received. A sixth copy has been added to the manifest form and is to be mailed from the receiver to the generator to allow the generator to comply with this responsibility.
- We have expanded the generator registration requirements beyond that described in our Blueprint for Waste Management and will include hazardous waste discharges to municipal sanitary sewers and to private sewage works. This step will provide us with a much broader information base.

(4) Improved carrier standards including driver training programs and vehicle management requirements.
- Under this section of the regulation, drivers of vehicles handling liquid industrial and hazardous wastes will have to be trained in areas such as emergency management, occupational health and safety and the relevant legislation.

IMPLEMENTATION AND COMMUNICATIONS

For the past 12 months, Ministry staff have conducted a mass communication plan.

The plan included:
- Putting together an extensive communications package. This package includes detailed guidance manuals to assist industries to comply with the new requirements. The manuals are intended to walk generators through the registration process using flowcharts, diagrams and explanations.
- Fact sheets, booklets and an audio slide show to provide information to the public and industry.
- As part of our preparations, we have conducted a registration trial run on 13 industries in Ontario.

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- Fact sheets, booklets and an audio slide show to provide information to the public and industry.
- As part of our preparations, we have conducted a registration trial run on 13 industries in Ontario to ensure that practical field problems are minimized and the guidance manuals can be clearly understood by industry. This trial demonstrated that the regulation will not only protect our environment but that it is understandable and workable to industry.
- In the three months before the regulation became effective, the Ministry conducted an intensive field communications program. The program included direct mailings, seminars, and ads in trade journals.

  The direct mailings provided an information package tailored to the needs of the client group. They were mailed directly to:
  1. approximately 18,000 known and suspected generators;
  2. all licensed carriers;
  3. all licensed receivers.

  In addition, there was a mailing to all those individuals and organizations who commented on the Blueprint.
- 68 seminars were given to trade associations, other similar organizations and their members to outline the regulation and its requirements as well as to answer specific questions raised by industry. These seminars were tailored to each industrial sector through specific examples.

REVISIONS UNDER CONSIDERATION

Additional revisions to the Regulation are now being prepared. These revisions are intended to streamline the Regulation and encourage legitimate recycling, while at the same time ensuring effective waste management practices. The proposed revisions include:

- A reduction in paper work for field operations such as construction, equipment servicing and emergency response operations. With this amendment, registration and manifesting would not be required, provided the waste(s) were properly managed within the company's service organization. Standards for service facilities would be provided by regulation.
- Recycling exemptions for wastes used as waste water treatment chemicals. This exemption will consider these wastes to be raw materials. As such, registration, manifesting and approvals for both the carrier and receiver would not be required.

- New regular reporting requirements for on-site disposal of subject waste. This amendment will require companies to provide records on a regular basis for wastes that are landfilled or incinerated on-site.

HAZARDOUS WASTE LISTING

With the implementation of Regulation 309, a mechanism was required to add new wastes and to delist existing wastes from the Schedules in the Regulation on a company-specific basis. Listings in the Regulation cover generic industrial processes and do not recognize specific process modifications that could render a waste non-hazardous.

An internal hazardous waste listing/delisting committee has been established to review these applications from industry. This committee includes a cross-section of experts from within the Ontario Government, including toxicologists from the Ministry of Labour. At this time, we have four applications under review.

To provide an avenue for public input into the process, an external advisory committee is being planned. This committee will review reports for listing/delistings prepared by companies and the internal committee and will make recommendations directly to the Minister. Under the terms of Regulation 309, amendments to the Regulation must be made before a new listing/delisting comes into effect.

ONTARIO WASTE MANAGEMENT CORPORATION

As you are probably already aware, the Province of Ontario has formed a Crown corporation to site, design, construct and operate a complete hazardous waste treatment/disposal facility. The corporation is in Phase IV of a five-phase program. A site in West Lincoln, a community in the Niagara Peninsula, has been selected for an integrated facility, including treatment/processing/ incineration and secure landfilling. At this time, the corporation is conducting intensive evaluations at the West Lincoln site. We anticipate that the formal environmental assessment documents will be complete and public hearings will be underway some time in 1987.

MUNICIPAL WASTE MANAGEMENT

While the existing Ontario Regulation 309 provides standards for landfill sites and associated design and operational requirements, these provisions tend to be general and ambiguous. Through the Blueprint for Waste Management process, the Ministry concluded that different levels of controls are needed for different types of landfill sites considering the site-specific nature of the facility.

Recently, the Ministry has circulated, for comments, proposed amendments to Regulation 309 in dealing with municipal waste management practices. We recognize that different requirements are needed for smaller and remote landfill sites as opposed to larger sites or those facilities that are close to population centres or other sensitive land uses.

Landfill sites are divided into 3 categories based upon separation distances from sensitive land uses: greater than 3 km, between 500 metres and 3 km and less than 500 metres. Each category is further divided into 3

classes, making a total of 9 classes of landfill sites, depending upon the site design capacities: greater than 100,000 tonnes, between 20,000 to 100,000 tonnes and less than 20,000 tonnes. Different levels of design and operating requirements will then be provided by the proposed regulation, from fencing and access control to ground water monitoring provisions. We expect this approach will be well accepted by municipal authorities across the province.

COMPREHENSIVE FUNDING PROGRAM FOR MUNICIPAL WASTE MANAGEMENT

For a number of years now, Ontario Ministry of the Environment has recognized the need to financially assist municipalities in the planning for waste management requirements and the operation of municipal sanitary landfill sites. Ontario has, in place, two major funding programs at this time.

(1) Waste Management Master Plan. This program provides up to 50% of the cost to municipalities for long-term comprehensive planning studies. The nature of the studies are consistent with the concept of Ontario's Environmental Assessment Act. It assesses potential locations and alternative technologies to be used for waste management facilities. Very often, a combined approach will be taken including different types of facilities such as landfilling, energy from waste or straight incineration. Waste 4R's (reduction, reuse, recycling or recovery) programs often become an important and essential component of the studies. Currently, there are about 20 studies underway.

(2) Waste Management Improvement Program. This program provides up to 100% of the total cost to municipalities for upgrading, closure and remedial measures for active landfill sites only. It covers activities ranging from installing signs and fences to hydrogeological studies and leachate monitoring systems.

At this time, the Ministry is exploring the possibilities of enhancement to the above two programs with additional funds. In addition to the program enhancements, we are also evaluating the need to financially assist municipalities for capital expenditures for the establishment and construction of various types of municipal waste management facilities including transfer stations, waste processing facilities and incinerators.

We like to approach this program in a comprehensive fashion, somewhat similar to our water and sewage program.

HOUSEHOLD HAZARDOUS WASTE COLLECTION PROGRAM

I would like to now turn to an area that is somewhere between municipal and industrial waste management. I would like to discuss an initiative recently introduced by the Ministry in Ontario, that is the "Household Hazardous Waste Collection program".

For some time now we have recognized that there is an inadequate solution for the average citizen to dispose of household wastes that are hazardous in nature, such as paints, solvents, pesticides and even crankcase oil from automobiles. After conducting a pilot project with the Regional Municipality of Waterloo (consisting primarily of the City of

Waterloo, Kitchener and Cambridge), having a total population of about 300,000, the Ontario Ministry of the Environment has recently launched a province-wide Household Hazardous Waste Collection program. The program will provide 50% funding with a maximum of $10,000 to municipalities towards the cost of conducting the event. The program will last for 3 years and, after that, a thorough assessment will be made to determine whether the program should be continued.

Along with the funding to municipalities, the MOE had produced technical and administrative guidelines to assist municipalities in actually implementing projects.

BIOMEDICAL WASTE

There were several major activities happening in Ontario for the management of biomedical waste.

(1) As a direct result of last year's amendments to Regulation 309 in dealing with hazardous waste management, we have observed an increase in the number of applications for certificates of approval to transport biomedical waste. Hospitals, medical laboratories and similar institutions are now required to register with the Ministry of the Environment as hazardous waste generators.

(2) Regulation 309 also requires hospitals with existing pathological incinerators to evaluate incinerator performance in accordance with Ministry's design and operating criteria and air emission requirements. Many hospitals have already retained consultants to conduct professional assessment of their equipment. Such reports are required to be submitted to the Ministry of the Environment by August, 1986.

These reports will be used by the Ministry of the Environment to determine the need for upgrading existing hospital incinerators on a crash basis. Provincial funding for equipment improvements is being considered at this time.

(3) For the past two years, an Interagency Task Force on Biomedical Waste has been working on a report to assess Ontario's biomedical waste management practices and develop strategies for its future management, along with recommendations on regulatory control requirements. The report has been submitted to both the Minister of Health and the Minister of the Environment.

(4) As part of our commitment to work with Environment Canada and other provincial agencies, Ontario is co-ordinating the development of national guidelines and standards, including operating and monitoring requirements for hazardous waste incineration facilities. To date in the biomedical waste area, we have revised the design and operating criteria for biomedical waste incinerators. We anticipate the development of new monitoring and maintenance requirements for biomedical waste incinerators by spring 1987. The intent is to develop national criteria for hazardous waste incineration, including performance standards, emission standards, operating procedures, monitoring requirements, and emergency shutdown procedures.

PCB WASTES

Most of you are probably aware that in 1984 Ontario Ministry of the Environment was a proponent in a lengthy public hearing process to establish a regulatory framework by which mobile PCB waste destruction facilities can be established in Ontario. Taking into account recommendations of the hearing panel, the Ministry has recently, in April of this year, introduced Regulation 148/86 for the operation of mobile PCB destruction facilities. The regulation, basically, provides the siting and operational criteria, including air emission standards and monitoring requirements. It exempts the operation of mobile facilities on public lands from environmental assessment requirements.

Three applications for Class II systems are now being processed. Class II systems are technologies based on chemical decontamination of mineral oils containing low levels of PCBs (<5000 ppm). Among the three proposals, PPM (Canada) Inc., Sunohio and Ontario Hydro, we hope that one of them could be in operation this year.

No formal application yet received for Class I facilities. Class I facilities are those utilizing high temperature destruction of waste containing high levels of PCBs, such as Askarels with up to 70% PCBs. Two tentative proposals have been under discussion. Both technologies are U.S. based.

Very recently, the Ministry has been seeking information or proposals from companies who might be interested in clean-up of the Smithville storage site which contains a wide range of PCB waste types.

WASTE SITE EVALUATION

For the last year or so, the Ministry has started a comprehensive waste disposal site evaluation program.

The purposes of the program are to:
(a) maintain a complete and accurate list of all active and closed sites;
(b) classify sites regarding potential impact on environment and human health;
(c) investigate the hydrogeology of high priority sites; and
(d) identify required remedial actions.

These purposes also indicated the types of work that are either presently being done or will be conducted. So far, the inventory contains 1500 active sites and 2000 closed sites.

At present, a preliminary classification of all sites has been completed and is being validated. Six sites are being investigated, requiring about $200,000 this year.

Future direction of this program involves intensive investigations and long-term monitoring of waste sites until they are judged not to be a hazard to human health and the environment. We believe this comprehensive program will prevent or, at least, minimize future incidents of problem sites which may require more resources for corrective actions.

LA GESTION DES DÉCHETS DANGEREUX AU QUÉBEC:

NOUVEAU RÈGLEMENT ET BILAN D'APPLICATION

Par Raymond Perrier, directeur général du Milieu terrestre

Il y a maintenant un an qu'entrait en vigueur le nouveau règlement québécois sur la gestion des déchets dangereux (15 octobre 1985). C'est pourquoi j'ai accepté avec plaisir votre invitation à participer à cette rencontre pour vous présenter ce nouveau règlement et pour faire le bilan de son utilité après douze (12) mois d'application.

Ce règlement sur les déchets dangereux remplace l'ancien règlement sur les déchets liquides, qui était en vigueur depuis 1975. Depuis quelques années, il était clair que cet ancien règlement avait besoin d'être mis à jour, adapté entre autres à une situation qui avait beaucoup évolué depuis dix (10) ans. Il nous semblait entre autres essentiel de doter notre Ministère d'un instrument juridique qui puisse accentuer nos moyens de contrôle et, de la sorte, constituer un outil de prévention efficace. C'est dans cette perspective générale que je voudrais dans un premier temps vous présenter ce nouveau règlement sur les déchets dangereux.

L'essentiel de ses dispositions porte sur trois aspects fondamentaux. Dans un premier temps, il définit de façon précise ce qui sera considéré comme un déchet dangereux. Ensuite, il aborde de façon exhaustive la question de l'entreposage dont il resserre considérablement les normes. Enfin, il met en place un système de contrôle du transport qui nous permettra de savoir en tout temps où se trouvent les déchets qui circulent et qui en est responsable.

Je voudrais aussi dans un deuxième temps dresser le portrait de l'utilité et de l'efficacité de ce nouveau texte réglementaire dont l'entrée en vigueur est échelonnée sur trois (3) ans.

Ainsi je vous présente le bilan du contrôle de la circulation des déchets au cours des derniers douze (12) mois. De plus le nouveau règlement a permis de mieux connaître les entreprises productrices de déchets dangereux au Québec ainsi que les volumes de déchets produits, entreposés ou éliminés.

Cette analyse de la situation confirme l'efficacité du nouveau règlement et la nécessité de certains ajustements qui seront apportés au texte réglementaire d'ici quelques mois.

QU'EST QU'UN DÉCHET DANGEREUX AU SENS DU NOUVEAU RÈGLEMENT ?

La définition de ce qui sera considéré comme un déchet dangereux apparaît dès le premier article du nouveau règlement. En fait, il s'agit d'un point majeur qui n'était pas couvert par l'ancienne réglementation. Je vous signale en passant que cette préoccupation de définir les déchets dangereux dans un instrument juridique n'est pas une originalité québécoise. Nos homologues de l'Ontario et de l'Alberta ont élaboré des définitions comparables tout comme les États-Unis et plusieurs pays européens.

En pratique, notre définition est fondée sur deux types de critères. Nous avons d'abord inclus au règlement une liste de 120 catégories de déchets produits par les divers secteurs des industries québécoises. Il s'agit:

- du traitement et du revêtement de surface
- de la chimie organique
- de la métallurgie
- du raffinage du pétrole
- du traitement des déchets
- de la tannerie

Quelques autres déchets importants mais impossibles à relier à ces sept catégories industrielles ont été ajoutés dans une section spéciale mentionnée en "divers". Ces substances constituent la base des produits qui sont susceptibles de se retrouver dans les résidus industriels québécois auxquels s'appliquent le règlement.

Dans un second temps, nous avons défini une série de caractéristiques qui rendent un déchet dangereux. Au règlement, on trouvera donc une définition précise et exhaustive de ce que nous entendons par "résidu corrosif", "résidu imflammable", "résidu lixiviable", "résidu réactif" et "résidu toxique".

Il s'agit en fait des cinq critères de base de ce que nous considérons comme dangereux. Par ailleurs, dans l'ancien règlement, seuls les déchets liquides étaient considérés. Au sens du nouveau règlement, les déchets dangereux peuvent aussi bien être liquides que solides ou gazeux. En pratique, celà signifie qu'on considèrera comme déchets dangereux les matières dangereuses périmées, les contenants contaminés de même que toute autre matière contaminée par des substances dangereuses, le sol contaminé par un déversement de produits toxiques, par exemple.

LA QUESTION DE L'ENTREPOSAGE

Permettez-moi maintenant d'aborder l'entreposage.

Parce qu'elle constitue un des maillons essentiels de tout système de contrôle des déchets industriels, la question de l'entreposage se situe bien sûr au coeur des dispositions du nouveau règlement. En général, on peut se dire que les exigences du Ministère sur ce point sont considérablement resserrées par rapport à l'ancienne réglementation. En pratique, cela signifie que dans beaucoup d'industries, il faudra procéder à certains ajustements plus ou moins importants.

J'aimerais traiter de cette importante question de l'entreposage en abordant d'abord certaines dispositions fondamentales et en dégageant ensuite les intervenants qui sont concernés.

Voyons d'abord les exigences fondamentales qui conditionnent toute notre approche.

L'entreposage doit être autorisé par le ministère de L'Environnement

Premièrement, pour entreposer des déchets dangereux, il faut obtenir une autorisation du ministère de l'Environnement. A proprement parler, cette obligation n'est pas nouvelle. Cependant, comme le nouveau règlement inclut aussi bien les déchets dangereux solides ou gazeux que les déchets liquides, l'obligation d'obtenir une autorisation s'étend donc à des intervenants qui, autrefois, n'avaient pas besoin de telles autorisations.

Sur cette question de l'autorisation du Ministère, il faut distinguer deux catégories d'intervenants distinctes. La première catégorie comprend les producteurs et les utilisateurs. Les producteurs sont ceux qui exerce une activité qui produit un déchet dangereux et qui l'entrepose à l'endroit où il est produit. Il s'agit en fait du cas d'un grand nombre d'industries québécoises.

Les utilisateurs sont ceux qui entreposent des déchets dangereux pour les recycler ou les réutiliser comme matières premières. Un exemple de ce tupe d'activités est le recyclage des solvants usés que des entreprises québécoises réalisent actuellement.

Pour ce premier groupe d'intervenants, il faut obtenir un certificat d'autorisation en vertu de l'article 22 de la Loi de la protection de l'Environnement.

Le second groupe d'intervenants comprend le traiteur, l'éliminateur et le centre de transfert. Le traiteur est celui qui entrepose des déchets dangereux hors du lieu où ils ont été produits en vue de les traiter. C'est le cas par exemple d'une industrie qui effectuerait la séparation de l'huile et de l'eau pour permettre la réutilisation de l'huile. L'éliminateur est celui qui entrepose des déchets dangereux hors du lieu où ils ont été produits en vue de les éliminer. Les deux exemples d'éliminateurs les plus connus du Québec sont l'incinérateur de Tricil, à Mercier, et l'usine de fixation-solidification de Stablex, à Blainville.

Pour ce second groupe d'intervenants, il faut obtenir un certificat de conformité de même qu'un permis d'exploitation en vertu des articles 54 et 55 de la loi. Il faut, en outre déposer une garantie et avoir une assurance-responsabilité. C'est une disposition très importante du nouveau règlement qui n'apparaissait pas autrefois.

Dorénavant, pour être autorisé à exploiter un centre de traitement, d'élimination ou de transfert de déchets dangereux, il faudra verser une garantie de 100 000$ et se munir d'une assurance responsabilité civile de 1 à 5 millions de dollars selon la capacité d'entreposage prévue. Pour nous du ministère de l'Environnement, il s'agit de nous assurer que ceux qui exerceront des activités d'entreposage de déchets dangereux seront en mesure de faire face à toute éventualité.

Il faut respecter des normes de localisation et d'exploitation

Autre exigence fondamentale, il faut respecter des normes de localisation et d'exploitation sévères. En fait, les normes comprises au nouveau règlement sont beaucoup resserrées par rapport aux exigences de l'ancien règlement sur les déchets liquides. Sur la localisation par exemple, je signale entre autres que nous avons énoncé plusieurs exigences quant aux distances à respecter par rapport à certains types d'environnement ou à divers biens et équipements collectifs. Sur l'exploitation, par ailleurs, le nouveau règlement est plus explicite et plus exhaustif que l'ancien.

Ici aussi, il faut dégager deux situations différentes. En effet, nous avons distingué les installations qui existaient déjà avant l'entrée en vigueur du règlement et celles qui seront crées après son entrée en vigueur. Les premières ne sont pas soumises aux normes de localisation. Elles sont cependant soumises aux différentes exigences relatives à l'exploitation. Bien évidemment, les installations qui seront crées à partir de maintenant devront-elles être soumises aussi bien aux normes de localisation qu'à celles d'exploitation.

Pour faciliter l'application de ces normes de localisation et d'exploitation, nous avons produit un Guide de l'entreposage. Ce guide est un document complémentaire du règlement qui indique les meilleures techniques à suivre pour se conformer aux exigences de l'entreposage dans les diverses situations qui ont été prévues par le législateur. C'est donc un instrument essentiel pour bien appliquer le règlement. D'ici à quelques jours, il sera disponible dans les directions régionales du Ministère de même qu'à la Direction des substances dangereuses, à Québec.

On ne peut entreposer pendant une période indéfinie

Enfin, la troisième disposition fondamentale porte sur la durée maximale pendant laquelle on peut entreposer les déchets dangereux sur les lieux de leur production. Le règlement limite à un an cette période. Nos intentions sont claires sur ce point: nous voulons éviter que d'importantes quantités de déchets dangereux ne s'accumulent dans les arrière-cours des usines. Notre exigence, ici, s'appuie principalement sur le fait que nous disposons déjà au Québec d'installations capables d'éliminer, de traiter ou de recycler de façon tout à fait sûre une bonne partie des déchets industriels que nous produisons. Pour les déchets que nous ne pouvons pas éliminer actuellement au Québec, nous avons adapté l'échéancier d'entrée en vigueur de cette exigence. Nous y reviendrons d'ailleurs tout à l'heure.

Je signale que cette disposition s'appliquera un peu différemment selon que l'intervenant concerné existait ou non au moment de l'entrée en vigueur du règlement. Par exemple, eux qui existaient déjà le 15 octobre 1985 pourront prolonger la période d'entreposage d'un an en signant une entente avec le ministère de l'Environnement.

Le contrôle de la circulation des déchets dangereux

Venons en maintenant à l'autre aspect du règlement, celui du contrôle de la circulation des déchets dangereux.

Essentiellement, le nouveau règlement met en place un système de contrôle fondé sur l'utilisation obligatoire du manifeste. Il s'agit d'un système semblable à celui utilisé ailleurs au Canada et aux États-Unis. C'est aussi un contrôle "à priori", c'est-à-dire qu'il faut obtenir une autorisation du ministère de l'Environnement avant d'effectuer un transport quelconque plutôt que d'en informer les autorités du Ministère après coup, comme c'est le cas dans d'autres états.

Pour résumer et simplifier les choses, permettez-moi de vous décrire brièvement quelques unes des nouvelles obligations des trois principaux intervenants majeurs dans ce type de système.

L'expéditeur

Le premier intervenant est bien sûr l'expéditeur. C'est celui qui a des déchets dangereux à faire transporter, que ces déchets aient été produits par lui ou par d'autres. Vis-à-vis du manifeste, l'expéditeur a des obligations sur lesquelles je reviendrai tout à l'heure.

Cependant, le point nouveau sur lequel je voudrais insister particulièrement ici concerne la codification des déchets à transporter. En pratique, il faudra dorénavant que l'expéditeur nous dise exactement quel déchet sera transporté avant que nous ne puissions accorder une autorisation de transport.

Pour les industries productrices de déchets qui, éventuellement, devront les faire transporter vers un traiteur ou un éliminateur quelconque, cela signifie qu'elles doivent au plus tôt nous déclarer quels déchets elles produisent. De la sorte, nous serons en mesure d'autoriser rapidement le transport quand l'industrie le demandera.

Cette opération de codification des déchets est nouvelle et elle constitue une étape essentielle du système de contrôle du transport. En effet, pour nous, du Ministère, le premier élément nous permettant d'être assurés que le transport s'effectuera dans des conditions de sécurité acceptable est de bien connaître les cargaisons qui seront déplacées.

3.2 LE TRANSPORTEUR

Au sens du règlement, le transporteur est celui qui transporte des déchets, que ces déchets aient été produits par lui-même ou par d'autres.

Outre les obligations relatives au manifeste que j'aborderai tout à l'heure, le nouveau règlement comporte deux dispositions importantes pour les transporteurs. D'abord comme dans l'ancien règlement sur les déchets liquides, il faut détenir un permis du ministère de l'Environnement pour faire le transport de déchets dangereux. Le nouveau règlement a cependant quelque peu modifié les obligations relatives au dépôt de la garantie nécessaire pour obtenir un permis. Celle-ci, en effet, est augmentée à 50 000$. En outre, l'assurance responsabilité civile obligatoire passe à 1 million de dollars.

Une autre disposition importante porte sur les gestes obligatoires à poser en cas de déversement. Bien qu'il ne s'agisse pas d'une nouveauté en soi, il me semble important de rappeler à tous les transporteurs qu'en cas d'accident occasionnant un déversement, ils ont tout un train de mesures à respecter obligatoirement. Entre autres, il faut immédiatement prévenir le ministère de l'Environnement de même que le corps de police le plus apte à intervenir rapidement sur les lieux de l'accident.

3.3 LE DESTINATAIRE

Enfin, le destinataire est celui qui reçoit les déchets pour des fins de recyclage, de traitement, de réutilisation

ou d'élimination. C'est le dernier maillon de la chaîne du système de contrôle et il y joue un rôle important. Lui aussi a des obligations strictes vis-à-vis du manifeste. Entre autres, il sert d'intermédiaire à l'expéditeur pour ce qui est d'obtenir un numéro de circulation. Il doit en outre détenir une autorisation du Ministère, comme l'exigeait déjà l'ancien règlement.

3.4 LE MANIFESTE

Chacun de ces trois intervenants doit remplir une partie du manifeste. Le formulaire du manifeste indique la quantité et la composition des déchets transportés. Il donne aussi bien entendu les coordonnées exactes du transporteurs et du destinataire. En outre, il doit accompagner tout chargement du point de départ chez l'expéditeur au point d'arrivée chez le destinataire. Relié au système de contrôle du Ministère, le manifeste nous permet de suivre les déchets de leur point de départ en usine jusqu'à leur destination finale, qu'il s'agisse d'un lieu d'entreposage, d'un lieu de recyclage, un lieu de réutilisation ou un lieu d'élimination.

LE FONCTIONNEMENT PRATIQUE DU SYSTÈME DE CONTRÔLE

On pourrait illustrer tout le fonctionnement du système de contrôle mis en place par le règlement par un tableau comprenant huit étapes, du type de celui que vous voyez présentement. Vous remarquerez tout de suite les trois intervenants dont je viens de vous parler, l'expéditeur, le transporteur et le destinataire. Le quatrième intervenant est le ministère de l'Environnement.

Première étape

Elle consiste en un échange d'information entre l'expéditeur-producteur de déchets et le ministère de l'Environnement. C'est l'étape, que j'ai déjà mentionnée, de la codification des déchets du producteur. L'industrie déclare alors au ministère de l'Environnement les déchets qu'elle produit.

A l'étape 2

L'expédieur prend contact avec le destinataire pour lui décrire la cargaison prévue et lui demander s'il est en mesure de recevoir le déchet. Il lui fournit également les coordonnées du transporteur.

A l'étape 3

Le destinataire prend contact avec le système de contrôle et communique le contenu de la cargaison prévue, de même que les coordonnées du transporteur.

A l'étape 4

Le système de contrôle émet un numéro de circulation au destinataire.

A l'étape 5

Le destinataire communique le numéro de circulation à l'expéditeur. Celui-ci doit alors faire signer le manifeste par le transporteur lors du chargement

A l'étape 6

L'expéditeur remet le manifeste et la cargaison de déchets au transporteur.

A l'étape 7

Le transporteur apporte les déchets au destinataire et lui remet le manifeste et la cargaison. Le destinataire doit alors remplir sa portion du manifeste et l'envoyer au ministère de l'Environnement.

A l'étape 8

Le destinataire confirme à l'expéditeur et au système de contrôle qu'il a reçu les déchets.

Voilà brièvement présentés les trois principaux volets du règlement que je vous avais annoncés au début de mon intervention. J'aimerais maintenant mettre en lumière un certain nombre de points supplémentaires qu'il me semble important de vous présenter.

4. LA QUESTION DE L'HUILE USÉE

Ceux qui connaissent bien le nouveau texte de règlement ont remarqué que nous avons fait une place spéciale à la question de l'huile usée. Ici, nous avons voulu favoriser le recyclage de ces huiles qui, au fond, ne devraient jamais être considérées comme des déchets.

Dans cette optique, nous avons facilité la collecte. C'est pourquoi, nous avons assoupli certaines exigences relatives au trasport. Ainsi, on n'aura pas à remplir le manifeste pour effectuer le transport.

En revanche, certains aspects du dossier des huiles usées ont fait l'objet d'exigences nouvelles. Par exemple, on ne pourra pas brûler d'huiles usées autrement qu'à des fins énergétiques, et encore, seulement dans une industrie ou dans des serres.

En outre, le nouveau règlement interdit l'utilisation de l'huile abat-poussière. D'abord, cette pratique d'épandre de l'huile usée sur les routes non pavées a parfois été source de contamination de l'environnement. Mais, surtout, elle entre en contradiction directe avec le principe que nous défendons et qui veut que les huiles usées ne devraient jamais être considérées comme un déchet.

Pour aider les industries qui auront à appliquer le règlement en ce qui concerne l'huile usée, nous avons produit un Guide de gestion des huiles usées. Comme le Guide d'entreposage, ce guide de gestion est un document complémentaire qui précise les exigences du règlement. On y trouvera entre autres des normes d'entreposage et de brûlage de même que des indications sur le recyclage.

LES MÉLANGES DE DÉCHETS SONT INTERDITS

Par ailleurs, le nouveau règlement interdit formellement les mélanges. C'est une disposition importante que l'on retrouvera aussi bien au niveau de l'entreposage qu'au niveau du transport. Certains assouplissements ont été prévus en ce qui concerne les usines de traitement des eaux usées. Mais, règle générale, nous avons été particulièrement exigeant sur ce point pour éviter entre autres que des mélanges inopportuns ne viennent créer de nouveaux déchets que nous n'avions pas à l'origine.

LES PRODUCTEURS DE DÉCHETS DANGEREUX DOIVENT PRODUIRE UN RAPPORT ANNUEL

Enfin, les producteurs de déchets dangereux devront dorénavant remettre au ministère de l'Environnement un rapport annuel présentant la nature des déchets produits, les quantités, le mode d'entreposage ou d'élimination, etc... Ce rapport doit également inclure une partie sur le déchets qu'on estime produite au cours de l'année à venir. La première version de ce rapport devra nous être remise le 15 avril 1986 et ensuite, à la même date à chaque année.

L'ENTRÉE EN VIGUEUR DU RÈGLEMENT

Comme je vous l'ai déjà mentionné au début de mon intervention, la grande majorité des articles du règlement entrent en vigueur le 15 octobre 1985. C'est une échéance que la plupart d'entre vous connaissez déjà.

Il y a cependant une exception à mettre en lumière ici. Elle concerne le délai maximal pendant lequel une industrie peut entreposer ses déchets sur les lieux même de production. Ici nous avons adopté une approche graduelle qui tient compte de la capacité des installations d'élimination actuelles au Québec.

Le délai est donc fixé au 15 octobre 1986 pour les industries qui, dès maintenant peuvent faire éliminer leurs déchets au Québec. C'est le cas entre autres pour tous les déchets inorganiques, qu'on peut faire traiter à l'usine de Stablex, à Blainville. Les secteurs industriels touchés par cette échéance sont les suivants:

- la première transformation des métaux
- la fabrication de produits métalliques
- le matériel de transport
- les produits électriques et élecroniques
- les poduits chimiques inorganiques d'usage industriel.

L'échéance pour l'élimination des déchets entreposés est fixée au 15 octobre 1987 dans les secteurs suivants:

- les produits en caoutchouc
- le papier et les produits en papier
- les produits du pétrole et du charbon
- l'imprimerie
- l'édition et les industries connexes.

Enfin, au 15 octobre 1988, tous les secteurs manufacturiers du Québec seront soumis au délai d'entreposage maximal d'une année.

LES SANCTIONS PRÉVUES

L'efficacité d'un tel règlement est en partie déterminée par la rigueur avec laquelle les infractions seront réprimées. Le nouveau règlement prévoit donc pour les contrevenants des sanctions substantiellement plus sévères que ne le faisait l'ancien règlement sur les déchets liquides. Pour un individu, les amendes peuvent aller de 1 000$ à 25 000$ pour chaque infraction. Pour les corportations, les amendes pourront varier 100 000$. Des peine de 2 500$ à nes d'emprisonnement peuvent également s'ajouter ou remplacer les amendes.

UN OUTIL DE PRÉVENTION EXHAUSTIF ET SIMPLE

Ce règlement, comme vous pouvez le constater, est donc un outil exhaustif en ce sens qu'il aborde toutes les étapes importantes de la gestion des déchets dangereux, aussi bien en ce qui concerne la définition même du déchet, qu'en ce qui concerne l'entreposage et le transport. Il les aborde également dans une optique adaptée au contexte actuel. En cela, il est tout à fait comparable au règlement que de nombreux autres Etats ont adopté sur la question des déchets dangereux.

Mais aussi, c'est un règlement plus simple qu'il n'y peut paraître à première vue. Entre autres, les obligations des divers intervenants potentiels sont clairement définies. En outre, les précisions qui y sont apportées sur la définition même des déchets dangereux vont simplifier la tâche aussi bien des industries que des responsables du contrôle. Une fois passée l'essentielle période de rodage des hommes et des systèmes, l'introduction de cette nouvelle réglementation ne derait donc poser aucun problème.

Tout au cours de cette période de rodage, en tout cas, le ministère de l'Environnement sera tout à fait disposé à accorder son aide à ceux qui en exprimeraient le besoin. Déjà, nous avons produit un certain nombre de guides techniques visant à expliciter

plus en détail certaines dispositions du règlement. D'autres suivront si nécessaire. En outre, la Direction des substances dangereuses de même que nos directions régionales sont prêtes à traiter de façon exhaustive toute demande d'aide ou d'information sur l'application pratique du nouveau règlement. C'est particulièrement le cas pour les industries qui devront mettre à jour leurs divers certificats d'autorisation ou permis d'exploitation pour les rendre conformes aux nouvelles exigences. Je vous assure qu'elles trouveront au Ministère une aide efficace et empressée de même que des hommes et des femmes animés d'un souci constant de service à la clientèle.

C'est qu'au fond, ce nouveau règlement constitue pour nous un outil essentiel de prévention. En présentant l'automne dernier le projet de règlement en conférence de presse, le ministre, monsieur Adrien Ouellette, avait particulièrment insisté sur ce point. Il avait rappelé entre autres que la gestion actuelle des déchets dangereux au Québec présentait des lacunes qu'il fallait corriger au plus tôt. Et les 317 cas qui figurent à l'inventaire des lieux d'élimination de déchets dangereux que le Ministre a réalisé au cours de 1984 confirme que nous héritons d'un passé pas toujours reluisant.

C'est cette lecture de la situation qui nous a amené à définir un plan d'action fondé sur la restauration et sur la prévention. Dans cette perspective, la mise en vigueur du nouveau règlement constitue la pierre angulaire de nos efforts de prévention dont il faut bien comprendre que la santé et l'environnement des générations à venir en dépendent.

LEGISLATIVE TRENDS - WASTE ISSUES

William Bertera
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This paper addresses several social, economic, political and environmental trends that are beginning to manifest themselves in waste legislation in both Canada and the United States. While it uses several examples drawn on the American experience, the reader will recognize parallel developments in Canada. The forms of governments are different and the political structure divergent, but the desire to protect the environment and the public health is international and environmental politics bear common characteristics, especially with respect to waste disposal. While the United States can justly be credited with pioneering efforts in many areas of environmental control, some of the most useful lessons can be derived from how poorly we have handled disposal issues, particularly those associated with solid wastes.

LEGISLATIVE BACKGROUND

Prior to the late 1960's, before Love Canal and the Valley of the Drums and all the attention they generated, waste management legislation, and indeed most other environmental public policy, addressed obvious instances of environmental degradation such as auto and sulfuric emissions and point source pollution of surface waters. Emphasis was on the short term, easily and obviously measured, and on acute public health concerns. The role of the national government in environmental legislation, generally, was that of providing overall standards and public policy guidance. In the United States, implementation of national environmental strategies was largely left to the state with the federal government providing financial incentives for that implementation. There was comparatively little actual federal involvement in the implementation of it's own programs.

Our unfortunately abrupt introduction to the serious effects of the mishandling of hazardous wastes in particular, and our growing knowledge of the long term chronic effects of the introduction of toxic substances into our environment brought forth a public outcry for substantial national legislation.

In 1972 the Solid Wastes Disposal Act was passed with references to inventories of solid waste disposal sites and to the establishment of certain criteria to adjudge the nation's solid waste disposal sites as either acceptable or not. Unacceptable sites were to have been closed within 5 years. Then came the Resource Conservation and Recovery Act, an important piece of legislation whose primary focus was on a pro-active approach to addressing the future disposal of hazardous wastes. And finally in 1980 the Comprehensive Environmental Response Compensation and Liability Act (Superfund) whose purpose was specifically to address the cleanup of existing or abandoned hazardous waste sites, the funding of which was to be accomplished by a tax on generator feed stocks if responsible parties could not be identified or their resources were inadequate to the task.

In the intervening years, the Congress also passed several pieces of major environmental legislation which, while not directly addressing the disposal of either hazardous or solid wastes, have come to have important impacts on both. Air emission standards, for example, have become important considerations in the

incineration of hazardous wastes as well as in resource recovery technologies. The Safe Drinking Water Act, which became law well over 10 years ago, is just now emerging as an important waste management statute as we struggle with a national groundwater policy which has important implications for the land disposal of both hazardous and solid waste, and is playing a major part in a growing trend to discourage and in some instances ban, the land disposal of not just hazardous but solid wastes as well. The effects of just this initiative alone are going to be a major focal point for those of us associated with disposal of all kinds of waste in the next 10 years.

SOME DEVELOPING TRENDS

In this regard, most of the remarks in this paper address that very important portion of the waste stream we euphemistically address as "solid" wastes and to suggest some important trends developing in the United States with respect to the disposal of those wastes. These trends, at least at present, are largely found in state and local legislative initiatives, but there is reason to think that many of them may soon be reflected in federal legislation and regulations as well. The trends as I see them are these:

(1) An inclination to consider all waste as hazardous and to require their disposal in facilities designed accordingly.

(2) A requirement to design solid wastes disposal facilities, regardless of local geological or hydrogeological characteristics to ultimate hazardous wastes design standards.

(3) An increasing inclination to discourage land disposal, regardless of other considerations, and increasing efforts for the outright ban of land disposal of solid wastes.

(4) Contradictory public policies with respect to the banning of wastes from other jurisdictions, an inclination to export waste if at all possible, and if not, to reserve existing capacity solely for waste generated within a geopolitical boundary irrespective of natural waste sheds.

(5) A growing public perception, encouraged by lawmakers, that resource recovery and recycling technologies are capable not just of supplementing but replacing sanitary landfills.

For those who thought the changes brought by the awareness of the effects of improper hazardous waste disposal were revolutionary, the next several years are going to bring about even more pervasive changes in the area of solid waste disposal. Those changes are going to be felt in ways that will make the social and economic impact of the hazardous waste legislation of the past 15 years seem insignificant in contrast.

While public concern about environmental degradation is intense, it is safe to say that most of the general public has remained untouched by the direct costs of reducing that degradation, particularly as it relates to hazardous waste. Although just about everyone recognizes they indirectly bear a portion of that cost, very few can attribute those costs to a direct effect on their personal finances. That will not be the case should current trends in solid waste disposal legislation be carried to their ultimate conclusions.

Every person and every large and small business alike generate significant quantities of solid waste each year. Addressing the disposal of that waste will bring the cost of disposal home to everyone because those costs will be high enough and direct enough to significantly effect personal and business budgets alike. The resulting economic and social choices and decisions will become as pervasive a force in national politics as they are now at the local level.

Most of the changes in waste management law in the next 10 years will come from a basic fear and mistrust of the land disposal of all wastes. Partially as a result of our experience with the improper disposal of hazardous waste, and the attendant public trauma that resulted therefrom, the general public is not confident that we can safely dispose of our waste by burying it.

Unfortunately, their fears are not groundless. Many of the solid waste land disposal facilities in North America do not meet state-of-the-art disposal technology standards. Some of them do not meet those standards simply because they are little more than holes in the ground. Others do not need them because the standards for what is state-of-the-art have and are constantly changed over the years.

THE ROLE OF RECYCLING AND RESOURCE RECOVERY

Presuming that we cannot safely bury waste in the future on the basis that we have not in the past is foolhardy and very costly. It is costly because it precludes from our consideration and from our disposal options what for most communities is the only sensible disposal decision for their solid wastes, at least in the foreseeable future, i.e. sanitary landfilling.

The options most often voiced as alternatives to sanitary landfills, recycling and resource recovery, are not disposal options at all, but simply volume reduction technologies. Neither, either separately or in combination, can displace the land disposal of waste - they can only extend the life of that capacity.

In the case of recycling, it is a simple matter of economics. Recycling is more than separating wastes into piles of reusable materials. It is the capacity to return those materials to commerce. There has to be a market for the recyclable material in order for recycling to have taken place. For all the good things we hear about recycling, the fact remains that the market for recyclable materials is inconstant and undependable, not only on a year to year basis, but on a geographic basis as well. Separating materials only to be forced to eventually bury them for lack of markets is not a sensible public policy. If simply separating materials itself created markets, there would not be an 11 year supply of ferrous metals sitting in scrapyards in the United States today.

Resource recovery, the transformation of a waste stream into an energy product, either a refuse-derived fuel, steam, or electricity, is a different matter than recycling. Resource recovery is a viable volume reduction technology and any community considering options with respect to it's waste management that does not consider resource recovery along with recycling is negligent. The problem with resource recovery is that it too is, in most instances, an economic rather than an environmental option.

Simply having garbage to burn is not sufficient to make an economically viable resource recovery project. There must also be a market for the energy, there must be sufficient wastes of a given quality to match the technology of the facility, and the economics must be such that the facility can compete on the open market for wastes. If it cannot, if there are more economically attractive alternatives such as a well run sanitary landfill, the facility will not be able to attract waste except through a legislatively mandated forcing of the waste to that facility.

Environmental and public health concerns notwithstanding, economics and finance have proven to be a crucial characteristic in the equation of most public policy decisions regarding resource recovery projects in the United States. Other considerations aside, this is because people resent having to pay to get rid of something which no longer has economic or useful value to them. There are

scores of technically workable resource recovery proposals that have fallen by the wayside in the last 10 years, not because they were technically deficient, but because the projects' economics were faulty.

THE DISPOSAL DILEMMA

And therein lies the public policy dilemma with which we are going to have to wrestle. On the one hand, a fear of the land disposal of solid wastes, and on the other hand, what will be a growing unwillingness to pay the high cost of the attendant technologies when there are competing alternatives. Much of the general public, and policy making alike, still do not realize that inevitably there is no alternative to the burial of solid wastes. Even with resource recovery, landfill capacity is extremely important not only for residue, but for noncombustibles and for diversion of capacity.

The problem is that we are proceeding as a matter of national policy to reduce our land disposal capacity while not sufficiently generating additional alternative capacity to make up the shortfall. In certain localities in the United States, and in fact in some instances in whole states, we now face a disposal capacity crisis simply because we have closed down existing landfills, not provided for the siting of sufficient new landfills, while at the same time having been unable to attract and develop resource recovery or recycling programs to diminish the volumes of waste that are continually being generated.

New Jersey claims it has only two years landfill capacity left in the whole state and yet they have no resource recovery plants in place and only one under construction.

The situation is exacerbated by a growing belief that there is little difference between the environmental effects of a well run sanitary landfill and of an improperly run hazardous waste land disposal facility. That kind of thinking is being encouraged in the United States not only by our experience with relatively old sanitary landfills, but now by our federal government which seems inclined, if not otherwise diverted, to require that sanitary landfills, in order that they be designated "acceptable", meet design criteria which are little different than those which have been established for hazardous waste facilities.

Little consideration seems to be given for local geological considerations or management practices. This too will diminish the number of existing sanitary landfills much as did hazardous waste legislation reduce the number of available hazardous waste facilities.

To the extent that environmentally unsafe facilities are forced to close, my industry supports such efforts. Unsafe facilities either ought to be brought into compliance or closed, be they publicly or privately owned. But as a matter of public policy, it is foolishness to close facilities without at the same time creating viable options for disposal. Yet, this is just what is happening in the United States. The fact of the matter is that the garbage has to go someplace. If we foreclose our existing options without creating alternatives, we will be forced to do just what New Jersey is now doing. They are contemplating reopening facilities they were forced to close only because they have no alternative.

Well engineered, well managed, thoroughly regulated sanitary landfills are going to continue to remain the most sensible disposal option for most communities in your country and mine for the foreseeable future. We short-change ourselves by thinking otherwise. That being the case, it is not in the public interest to avoid our responsibility in encouraging the development of new landfill capacity built on existing state-of-the-art technology. To do otherwise itself creates an environmental crisis more severe than the one we now face. Had American communities, once realizing that existing facilities were unsafe, done

more than simply try to close them down -- had we instead begun developing disposal capacity that was state-of-the-art, that was safe, the disposal crisis that many communities are now facing would never have come to be.

SOME SUGGESTIONS FOR LEADERSHIP

We in the environmental community must bear much of the responsibility for what has happened. In our enthusiasm to create interest in environmental programs and to create support for their funding, we whipped the public into a frenzy of irrational fear and now we are bearing the fruits of that excess. It is incumbent upon us to provide a different kind of leadership, one that does not forego options but that encourages public policy decision making that bears some relationship to our real needs and realizable goals.

What would constitute such leadership? Here are some suggestions:

(1) A recognition that we cannot do without landfills, that they are the only real disposal option even when volume reduction technologies such as recycling and resource recovery are properly instituted, and that these facilities have to be sited in somebody's backyard.

(2) A recognition that disposal is not just an environmental and public health issue, but an important economic one as well, and that costs matter equally to consumers and taxpayers alike, and are a major consideration in their decisions.

(3) A recognition that risk assessment is not only a means of balancing public health considerations, but also a way of conducting cost benefit analysis for real world options. Risk is incumbent in all public policy choices, it can be accounted for but it cannot be eliminated and efforts to do so bear unacceptably high costs without demonstrable benefits.

(4) A recognition that public leadership -- political leadership -- is essential if solid waste disposal problems are to be solved, particularly with respect to siting new facilities.

MOBILE PCB DISPOSAL - A LOCAL COMMUNITY'S PERSPECTIVE

The use of mobile waste treatment and disposal facilities has been greeted with considerable interest as a possible means for addressing a variety of waste disposal problems. In Canada, most of this interest has focused upon the potential use of this technology to solve the particularly intractable problem of managing PCB wastes. While mobile incineration may have application in regions of the country where waste quantities aren't sufficient to justify permanent facilities, it is with respect to the potential use of this technology for the treatment of PCB wastes that this paper is primarily concerned.

As we are all aware, widespread awareness of and concern about PCBs has contributed to a social and political climate that has greeted virtually all disposal initiatives with a great deal of scepticism and anxiety. In Ontario, efforts to establish both consolidated PCB storage facilities and high temperature incineration have failed resoundingly. Communities are simply unwilling to assume the risks associated with the handling and disposal of PCBs, and governments are reluctant to confront the politically problematic choices that inevitably arise when a new scheme is announced.

Compounding this problem is, what may be described as, a growing crisis in public confidence in the ability of our laws and the will of public officials to ensure proper waste management practices that will adequately protect our health and environment. Decades of relative indifference to the environmental implications associated with waste management and disposal, have now arrived to haunt us in the form of hundreds of waste disposal sites leeching toxic pollutants into rivers, lakes and groundwater regimes.

Onto this scene has arrived a number of new waste management and disposal initiatives, among them being efforts to license and operate mobile PCB treatment and disposal facilities. An offshoot of technological developments designed primarily to address the problems presented by various superfund sites south of the border, mobile disposal has attracted a great deal of attention in various regions across Canada. Of particular appeal is the prospect that mobile facilities offer for overcoming the often insurmountable obstacles confronting a proponent seeking to establish a permanent hazardous waste treatment or disposal facility. The appeal of such a mobile approach to waste disposal is twofold. Billed as a local solution to a local problem, mobile disosal has been advanced to address the resistence of local communities to accept the risks associated with disposing of wastes from both near and far. The notion might well have particular appeal to a community that found itself the repository of PCB waste that it would otherwise simply have to store. In

addition the very mobility of the facilities would mean that any particular operation could be sited strictly on a temporary basis. Thus no particular community would have to accept the long term and ongoing risks associated with a permanent operation. To many, the appeal of mobile waste treatment may be considerable.

Proponents of mobile waste disposal, both within and outside government, were soon confronted however by regulatory and licensing regimes that have been established with permanent facilities in mind. To some, the public hearing processes that now generally attend undertakings to establish waste management facilities would be far too arduous, time-consuming and costly for a proponent of mobile treatment. For that reason, during the early 1980's the Ministry of the Environment in Ontario undertook an initiative designed to streamline the regulatory and licensing process in order to facilitate mobile disposal operations. The Ministry's approach was essentially to spell out, in a mobile PCB disposal regulation the generic siting and operational criteria that would guide any endeavour to site and operate a PCB destruction facility. In doing so however, the Ministry would exempt such undertakings from the public hearing requirements that would otherwise govern this and any other hazardous waste management endeavour.

Subsequent proceedings before a Royal Commission convened specifically to facilitate public input with respect to the Ministry's proposal, resulted in numerous recommendations, many of which have been adopted as elements of the mobile PCB disposal regulation recently promulgated by the province of Ontario. Dividing the PCB management endeavour into three separate categories, public hearings have been maintained with respect to high level PCB waste management endeavours. PCB chemical treatment facilities however, will now be able to operate in Ontario without having to proceed through public hearing processes for each site at which the proponent may choose to operate. Arguably, the regulation represents a reasonable compromise between the need to establish a feasible regulatory process for mobile disposal while maintaining the participatory rights of local communities when the stakes are significant. In not allowing for full public hearings with respect to PCB treatment facility operations however, the regulation represents a calculated gamble. The risk is that in seeking to finesse local opposition, the mobile waste treatment endeavour may well backfire and put the solution to one of the most recalcitrant hazardous waste management problems even further out of reach.

Perhaps the best to illustrate the potential risks here is to imagine a "close encounter" with a mobile waste management undertaking from the perspective of a local community.

While a great deal to do with hazardous waste management treatment and disposal is uncertain and unpredictable, one constant is the apprehension, anxiety and finally, resolute

opposition that greets virtually all waste management proposals Notice of plans to operate a PCB disposal facility in a particular community will very predictably provoke a great deal of interest in the potential implications of that endeavour for public health and the environment. Unfortunately, notwithstanding the glare of media attention it is clear that from the general tenor of public reaction that there is very little accurate information about this substance. Thus even should the initiative involve a chemical treatment operation, there is very little likelihood that people in the community will appreciate the distinction between a contaminated oil at 3/100s of 1% PCB material and askarel. Clearly, a strong argument can be made for an aggressive campaign of public education that would enable communities to make informed judgements. Equally clear, however, is the fact that trying to inform a local community only after it has been chosen as a waste disposal or storage site, is particularly poor timing. A PCB disposal initiative may well provoke a crisis in the community and anything that government officials and scientists say in this context is often regarded as self-serving efforts either to overstate or understate the risks associated with PCB disposal endeavours.

If initial fears subside however, there is a very substantial risk that they will not remain quelled for long as the community learns that it will not have the participatory rights that it may have come to expect. Thus at that moment when a local community may be in particular need of objective information that it can trust, one of the most appropriate forums for conveying that information, a public hearing process, will not be available. The potential consequence of all of this is obvious and may well result in efforts to site mobile facilities being stymied. Less apparent however, are the implications that such a failed initiative may have for other waste management issues confronting that community and our society. Trying to inspire public confidence in government's ability to manage, waste management endeavours will arguably require clear and certain approaches to regulation that will, over time engender public confidence. If a fixed facility or a sewage sludge treatment operation is to be routinely subject to public hearings then a community may well ask why a PCB waste management endeavour wouldbe exempt from the regulatory requirements that are applied routinely to far less controversial undertakings. The risk here is also that local and regional municipalities' often painstaking efforts to establish waste treatment facilities may well be put off the rails by controversy involving mobile operations.

Another potential risk associated with abolishing public hearings with respect to mobile facilities is that the quality of the licensing decision itself may well suffer. There would, I hope, be general agreement that informed public participation often results in substantive and substantial improvements to any undertaking that has come forward for public review and scrutiny. Often the prospect of the glare of public scrutiny will shake

down any deficiencies that remain in a particular proposal. Given the character of the risks associated with hazardous waste management and disposal, even when carried out on a temporary nature, it is incumbent upon all of us to ensure that absolutely no risks are taken that might otherwise, with prudent and thorough planning, be avoided.

It is clear from the preceding remarks that as, an exponent of participatory rights, I have considerable reservations about the wisdom of derogating from those rights, particularly in light of the public interest and concern over waste management issues. I believe that the rationales for maintaining full participatory rights are strong ones that should only be departed from if thoroughly and rigorously justified.

The task before us is one that will require all in society to accept a great deal more responsibility with respect to the ways in which we generate and dispose of wastes. Perhaps the silver lining in the numerous clouds that dot the horizon of the waste management enterprise is that difficulties associated with this endeavour may finally prompt public support and funding for recycling, reduction and re-use initiatives that will obviate the need for building ever larger faclities to manage ever increasing volumes of waste, refuse, and effluent. Until this utopia arrives however, it will be incumbent upon all ourcommunities to accept the responsibilities associated with variety of waste management and treatment endeavours. If the local community however, is to shoulder the responsibility of being the home of a waste disposal site, it must also be given the authority to influence and participate fully in the decision-making process that may well have that result. In the words of the Ontario Blueprint on Waste Management "unless the residents of Ontario are given the fullest opportunity to express their views and concerns, beginning at the earliest stages of waste management activities, there is a danger of misunderstanding, mistrust and confrontation".

Another important rationale for and strength of the public hearing process is that it is arguably particularly well-suited to making the very difficult decisions that must be exercized in determining "acceptable" levels of risk, particularly when those risks involve exposures to highly toxic substances. Many of you present here today are more than familiar with the very sophisticated risk assessment procedures that are designed to determine the risk of excess cancers or deaths associated with exposure to trace elements of the by-products of incineration processes. Having sat through more than one explanation myself, the process seems to be a morbid version of the perennial dilemma concerning dancing angels on the head of pins. The point is that obviously many of the decisions involved in any hazardous waste management endeavour are matters of social policy and not predominantly scientific or technical.

One of the problems in this area is the public expectation of the scientific community that it deliver a great deal more certainty than it is capable of. Clearly information must be more readily available so that people can appreciate that, while many decisions should be informed by scientific judgement, they are at the end of day, matters that people and communities are capable of deciding for themselves. Again if we are going to expect people to accept some measure of responsiblity for dealing with the problem, every opportunity must be given to them to particiate in the decision-making process and to become informed about all of the issues involved.

Mobile waste treatment may well prove to be an important tool for resolving some particularly problematic waste issues, particularly in the absence of available or sufficient permanent facilities. The promise that mobile treatment offers for dealing with waste on a regional basis, where quantities would not justify the establishment of a permanent facility or of addressing other waste management problems that must be dealt with on an urgent basis, are attractive ones. The risk associated with seeking to facilitate mobile initiatives are however quite real and it is incumbent upon all of us to proceed with a great deal of caution and prudence so as to avoid all steps that may in exacerbating existing tensions and retard solutions rather then speed them.

THE APPROVALS PROCESS-PATIENCE IS A VIRTUE PERMITTING OF THE EXTENSION TO THE TRICIL (SARNIA) LIMITED INDUSTRIAL WASTE LANDFILL

ERIC HUNTER
TRICIL (SARNIA) LIMITED

Tricil is a major Canadian waste management company which operates 23 facilities in Canada and the United States. The operations provide collection, treatment, energy recovery and disposal for a wide range of domestic, commercial, industrial and hazardous wastes.

In Moore township, near Sarnia in South-Western Ontario, Tricil has operated, for the last 13 years, the major industrial waste treatment and disposal facility in Ontario. At this location we operate a three-year-ol high temperature liquid waste incineration system and a secure chemical landfill.

The facility is also the base for Tricil's fleet of industrial waste transportation vehicles serving Ontario.

In 1982 Tricil started a project to extend the secure chemical landfil operation onto adjacent company-owned property, then in use as farmland.

The extension required changes in the official land use designation ar certification under the Environmental Protection Act of Ontario. These requirements led to a public hearing under Ontario's Consolidated Hearings Act.

Discussion of our preparation for the project and the hearing was presented at last year's Canadian Waste Management Conference, however si the hearing was still in session, I was unable to comment in any detail o the hearing itself.

Today I will recap briefly the preparation and the project and will comment on our perceptions of various aspects of the process.

The project team developed in 1982 included the following disciplines and areas of expertise:

Business	-Public Affairs & Communication -Accounting -Marketing
Engineering	-Chemical & Process -Mechanical

Hydrogeology	-Geology -Hydrology -Civil Engineering
Environmental Impact	-Socio Economics -Air/Surface Water -Agriculture -Land Use & Planning -Terrestrial Biology
Legal	-Applications -Counsel -Hearing Representation

Site investigations and analysis were completed in 1984 and indicated that the site, consisting of a massive clay till about 40 meters thick overlying a dense sandy till of up to 3 meters thick above the bedrock interface, would be hydrogeologically suitable for use as a secure chemical landfill. Hydraulic conductivity values in the clay till range from 10-8 to 10-9cm/sec, and the vertical recharge gradient varies from 0.03 to 0.2, resulting in a maximum groundwater flow rate of about 0.3cm year.

A design and operating plan was developed using an entombment process, wherein solid wastes will be placed in an 18 meter deep trench excavated in the massive clay till and capped with a 6 meter-thick clay cap, mounded to 1 meter above grade level. The site is ideally suited to an entombment landfill since the extremely low hydraulic conductivity of the clay till ensures that molecular diffusion will be the dominant migration mechanism.

Based on diffusion rates, contaminant solute species would first appear at the flow boundaries only after thousands of years and would remain within environmentally acceptable limits.

Investigation is continuing to determine if the weathered surface zone of the clay till provides a faster route for contaminant migration, so the entombment concept avoids placing wastes at depths less than 6 meters below surface.

As a further component of the design and operating plan, detailed monitoring and contingency plans were developed and closure and post-closure activities were defined.

The environmental impact analysis indicated that the proposal would have no significant impact on the surrounding area and identified several mitigatory measures, primarily aesthetic in nature.

Public affairs and communications activities formed an important part of the project and this was addressed by my colleague Bob Redhead during yesterday's session. The objectives were to ensure that the various

interested publics were made aware of the progress and detail of the application and were able to provide comment wherever necessary.

We developed a comprehensive set of application documents and made sure that copies were available to all interested groups well in advance of the hearing. We prepared several summaries in various lengths and detail and we created many visual aids for use at news conferences, public workshops and at the hearing itself.

In our regular newsletter, "Common Ground", which contains information about waste management, environmental protection, Tricil's activities in general, we included detail and progress reports on the Landfill extension application.

We met with representatives of all the audience groups to explain and answer questions on the proposal. We held a series of public workshops in the local community, evenings and weekends, to discuss the application and receive comment and criticism from our neighbours. We had the plant open for inspection by anyone who wanted to visit and we talked to local service groups, teachers, school children, naturalist groups and politicians.

Throughout the entire exercise we kept the media well informed with phone calls, news conferences, news releases and one-on-one interviews.

By August 1985 we were ready for the public hearing. On August 19th a preliminary hearing was convened by a panel consisting of a representative of the Ontario Municipal Board and a representative of the Environmental Assessement Board, where participants in the Hearing identified themselves as:

-Ontario Ministry of the Environment

-Township of Moore

-Ontario Waste Management Corporation

-Pollution Probe Foundation

-Canadian Environmental Law Association representing Lambton Anti-Pollution Association

-5 Neighbouring Landowners

The hearing reconvened on September 16th, 1985 and remained in session until December 4th with a break of 6 weeks due to prior committments by the panel members.

At the Hearing the rules of evidence applied and each participant was required to present his case either directly or with the assistance of counsel and to submit to cross examination by the other parties and by the

hearing panel. This may appear to be rather tedious, however on many occasions the wisdom of this formalized procedure kept the process on track and objective.

As would be expected, most of the evidence dealt with the technical details of the application and their interpretation, technical experts being called by both Canadian Environmental Law Association and Pollution Probe. Ontario Waste Management Corporation, although they initially declared themselves supportive of the proposal, chose to introduce technical evidence through cross-examination by counsel, briefed by technical experts. This technique proved to be time consuming, inefficient and extremely confusing to the process. Such evidence as they did introduce directly through witnesses, related to commercial, competitive and regulatory aspects.

Ontario Ministry of the Environment and the Township of Moore both entered evidence directly through competent technical witnesses.

A hearing such as this is an adversarial process and however much we may try to find some common ground amongst the parties there will always be residual areas of disagreement. To listen to evidence and to weigh and evaluate the relative positions is the role of the hearing panel and it is important that the participants present facts to support their position in a coherent and understandable way. I did say facts. The process deals with facts, not with impressions, opinions, emotions or wishes. The facts must be supportable by the evidence and in the range of possibilities and probabilities lie the areas of compromise.

Some time ago we heard much about the benefits of mediation in environmental matters. Could this be successful, could it eliminate long expensive environmental hearings? During our process there were areas of mediated agreement, however major fundamental points were adversarial and each party went to extremes to have its position prevail. So, based on our experience, mediation may have a role to play but will not replace the adversarial hearing process in instances of issue polarization.

The role of the Ontario Ministry of the Environment is misunderstood by some participants. The function of the Ministry at our Hearing was to assess the completeness of the application and the information supplied from a regulatory point of view, and to have its own experts review and evaluate the technical details and interpretations of the site investigation, operating plans and monitoring plans.

The Ontario Ministry of the Environment is <u>not</u> required to support or oppose an application other than by agreeing or disagreeing with the technical evidence. Indeed it is important that the Ontario Ministry of the Environment not identify closely with the proponent.

An equally strong misconception which occurs from time to time is that the Ministry is the champion of the people and should support their concerns. Obviously, in its role as regulatory and technical reviewer, the

government agency cannot take a partisan position in this area anymore than it can support the proponent. However, government support at the political rather than the staff level is something to which all citizen groups and intervenors aspire.

In our case citizen intervention and objection was mounted by The Lambton Anti-Pollution Association, a local interest group and by the Pollution Probe Foundation. Both these groups participated actively in cross-examination and both presented testimony from expert witnesses. It was perhaps unfortunate that, in spite of the very detailed communications efforts undertaken by the proponent for eight months before the hearing, these expert witnesses were unfamiliar with major aspects of the proposal. The intervenor's experts often presented evidence based on their experience at other sites, in other jurisdictions and suggested alternative proposals based on opinions and hypotheses, unsupported by facts. This inequality of evidence tended to broaden the gap between the proponent and the intervenors and to further reinforce the adversarial aspects of the hearing process. It also tended to move the differences into a more emotional field and several times during the Hearing this resulted in radical overstatement to the media in an attempt to create sensational headlines.

All of this comes as no surprise--when one looks at the activities of many environmental activist groups the tactics are similar, an overstatement of partial truths to create an emotional response and contentious media coverage. Such histrionics create good news stories and add fuel to the fire of disagreement but often do little to arrive at a solution which is in the public interest.

Based on opinion surveys which we have undertaken over the past five years, members of the public rely on information provided by environmental groups in preference to that supplied by government or industry. Thus an environmental group which purports to act in the public interest has a responsibility to provide accurate information and not to deal in emotions, if it is genuinely committed to advancing environmental protection.

Another important participant in the Tricil hearing was the Ontario Waste Management Corporation, a crown corporation funded from the public purse by the Ontario Government since its formation in 1981. In addition to a rigorous investigation through cross-examination of the technical details of the proposal Ontario Waste Management Corporation petitioned for a limited term of approval, on the basis that at some time in the future they would be in operation with superior technology and thus the Tricil facilities would no longer be appropriate or required. This position was viewed by Tricil as an attempt to apply a commercial rather than environmental constraint to the proposal, since such an unprecedented condition had not been previously applied under environmental legislation. Introduction of commercial and competitive issues into an environmental and land use hearing should be avoided, and in fact, in its ruling the Board did not see fit to implement such a restriction.

The panel convened a further day's hearing early in February of this year to address the issue of costs. Several of the intervening parties, Moore Township, Lambton Anti-Pollution Association, and Pollution Probe, petitioned the Board to rule that the costs of their participation should be borne by Tricil. The costs requested covered legal fees, expert witness fees, staff salaries and disbursements to a total of approximately $100,000. Before the hearing commenced the Ontario Ministry of the Environment had approved funding for Lambton Anti-Pollution Association and for Pollution Probe to a total of $18,000.

In April this year, 4 months after the end of the hearing, the Board issued its decision. The Board directed the Ontario Ministry of the Environment to issue a Certificate of Approval with 16 operating conditions and directed the municipality to make the appropriate land use and Official Plan changes.

The Board also directed that Tricil pay costs to Moore Township, Lambton Anti-Pollution Association and Pollution Probe in the amount of $91,000.

On receipt of this decision, the Lambton Anti-Pollution Association lodged an appeal, in the form of a petition to Cabinet, in which they asked that the Board's decision be overturned and that the additional conditions they had proposed at the hearing be added to the Certificate. No further evidence was presented in support of this position, however the submission of the appeal prevented issuance of the Certificate for a further 4 months while Cabinet considered the position.

Looking back on the entire project some important points come to light. The process is complex, time consuming and expensive. The technical investigation and presentations must be of the highest quality and during development must be subjected to constant critical evaluation. Public involvement must occur as soon as possible and no efforts spared to convey information to the public and to receive and act upon their input. The due legal process must be observed with full participation from all parties. Commercial and competitive influences should not be allowed to interfere with the objectivity of the environmental hearing process.

Citizen and environmental intervenor groups should be well prepared to contribute to the hearing, not simply to interfere with and delay the proposal. Citizen intervenors should take advantage of all the information and technical assistance available from the proponent. They should not be reluctant to hold up their end of the public communication and participation process. This won't prejudice their ability to present their case at the hearing, but may save them a lot of time and effort chasing after spurious issues.

The inequality of factual evidence presents a difficulty and for the most part this cannot be effectively resolved through public funding or award of costs. Participation in the public communication process may be a more effective way of redressing the balance.

Finally, it is important the process afford the proponent a fair hearing for if the proposal is environmentally sound and in the public interest it should not be refused or constrained to further the interests of a public pressure group.

A REPORT ON THE FINDINGS OF SURVEYS IN THE UNITED STATES ON WASTE MANAGEMENT PRACTICES OF SMALL QUANTITY HAZARDOUS WASTE GENERATORS

BY

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(GRCDA)

PRESENTED AT THE
8TH CANADIAN WASTE MANAGEMENT CONFERENCE
SEPTEMBER 3-4-5, 1986
HALIFAX SHERATON HOTEL
HALIFAX, NOVA SCOTIA, CANADA

A REPORT ON THE FINDINGS OF SURVEYS IN THE U.S. ON WASTE MANAGEMENT PRACTICES OF SMALL QUANTITY HAZARDOUS WASTE GENERATORS

By H. Lanier Hickman, Jr.
Executive Director ,GRCDA

FOREWORD

This report provides the information received from three Small Quantity Hazardous Waste Generator surveys in the conduct of survey questionnaires we developed for specific groupings of small businesses. The survey was conducted by mail and telephone and through personal interviews. We feel confident that the results of the survey are truly reflective of the solid waste management practices of the small businesses surveyed. Quantification is less certain but still reflective of the types and quantities of hazardous wastes being generated by small businesses.

Readers of this paper are cautioned to recognize that the results of the survey may or may not be reflective of national practices and trends. There is a paucity of information about what small businesses do with their small quantities of hazardous wastes and what are the characteristics of those wastes. Hopefully, the results of the survey will aid in filling part of the need for information about small quantity hazardous waste generators.

H. Lanier Hickman, Jr.
Executive Director, GRCDA

ACKNOWLEDGEMENTS

This paper is a compilation of three reports prepared by GRCDA on surveys of small quantity hazardous waste generator waste management practices. The surveys were conducted in the fall of 1985 in the cities of Hampton, Richmond, and Lynchburg, Virginia; the counties of Chesterfield and Henrico, Virginia; the Puget Sound area in the State of Washington [the cities of Seattle and Tacoma, Washington; the counties of King, Pierce, and Thurston, Washington]; and the State of Delaware.

In Virginia the surveys were conducted by:

- Joe Kertesz, City of Hampton
- Carl Newby, City of Lynchburg
- Buddy Palmore, City of Richmond
- Don Nuttall, Chesterfield County
- Ed Morshedi & Bill Hase, Henrico County

Nancy Grundahl, USEP, Region III, Philadelphia, Pennsylvania, was the EPA project officer. H. Clayton Ervine, Technical Director, GRCDA, was the GRCDA Project Officer, and prepared the Virginia report.

In the Puget Sound area the surveys were conducted by:

- Jill Lowe, Seattle-King County Department of Public Health
- Joan McGilton, Seattle Solid Waste Utility
- Judith Lorbier, Tacoma-Pierce County Health Department
- Douglas Pierce,Tacoma-Pierce County Health Department
- Gary Kato, Thurston County Health Department
- Don Leaf,Thurston County Health Department

Other individuals who made measurable contributions to the effort include:

- Ron Hansen, King County Solid Waste
- Henry Sharpe, Puget Sound Council of Governments
- Sharon Greenman, Seattle-King County Department of Public Health
- Jeff Defenbach, Snohomish County Health Department
- Bill Larson, Tacoma Refuse Utility

Joan Cabreza, USEPA, Region X, Seattle, Washington was the EPA project officer. H. Clayton Ervine, Technical Director, GRCDA, was the GRCDA Project Officer, and prepared the Puget Sound report.

In Delaware, the surveys were conducted by:

- Jim Pase, Delaware Solid Waste Authority (DSWA)
- Jim Daimus, DSWA
- Barbara Lucas, DSWA
- Deborah Parkowski, DSWA
- Timothy Thomas, DSWA
- Virginia Drabbant, DSWA

Other individuals who made measurable contributions to the effort include:

- Wayne Ashbee, Delaware Division of Water Resources
- William Razor, Delaware Department of Natural Resources and Environmental Control, Office of Solid Waste
- Greg DeCowski, Delaware Department of Natural Resources and Environmental Control, Office of Solid Waste
- N.C. Vasuki, Delaware Solid Waste Authority

Nancy Grundahl, USEPA, Regionn III, Philadelphia, PA was the EPA Project Officer. Dr. Donald Shilesky was the GRCDA Project Officer and assisted in the preparation of the report.

H. Lanier Hickman, Jr., Executive Director, GRCDA, was the GRCDA Project Manager for all three projects.

The results of the survey efforts are reported in three reports referenced in the paper and in the reference listing at the end of the paper.

I. INTRODUCTION

A. Overview

Under support of a grant from the USEPA and the project management of GRCDA, the Delaware Department of

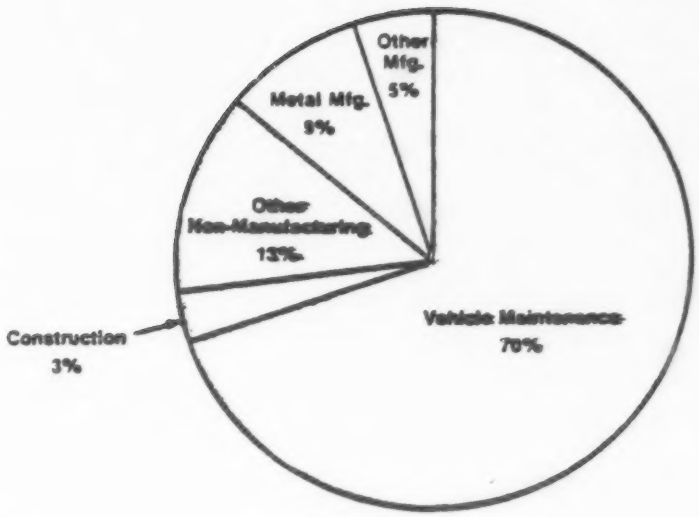
Natural Resources and Environmental Control; the Delaware Solid Waste Authority; the Cities of Hampton, Richmond and Lynchburg, Virginia; Chesterfield and Henrico Counties, Virginia; and the cities of Seattle and Tacoma and the counties of King, Pierce, and Thurston in the state of Washington cooperated in a project to:

- inform small businesses of the pending regulation of businesses which generate between 100-1000 kgs/mo of hazardous waste
- assist the small businesses to comply with the new regulations
- survey current waste management practices of small businesses

The purpose of the surveys was to define and survey those small businesses in the study areas which could be used to determine if existing institutional systems were adequate to properly manage these wastes originating from sources generating less than 1000 kgs/mo. The local governments and the State of Delaware hoped to be able to assist the businesses if deficiencies were found. The project was timely in view of the fact that EPA was required to regulate establishments which generate between 100 and 1000 kgs/mo. on or after March 31, 1986.

The survey population was defined as that used by the EPA in an earlier national survey.(1) Commercial lists of businesses were purchased for the survey. The lists were coded by Standard Industrial Classification (SIC) based on the EPA work. In Delaware and Virginia, survey questionnaires pertinent to specific business groupings were mailed to some 21,000 small businesses. Follow-up telephone surveys were conducted to a level that indicated that representative results were being obtained. In Washington only phone surveys were conducted. The total responses in the Washington study area was 870. In all three locations, about 10 percent of the universe were surveyed.

As mentioned, Abt Associates, Inc., under a contract with the USEPA, conducted a national survey of small quantity hazardous waste generators. The final report was submitted to the USEPA in February 1985 and was entitled, "National Small Quantity Hazardous Waste Generator Survey"(1). This report was based on responses from nearly 19,000 businesses and represents the definitive work done on this subject to this time. For this reason and so that the results of this project would be consistent in format with the data obtained by Abt, the efforts of the three survey efforts used the same industrial classifications (SIC) and waste designations. Figures from the Abt report showing national generator distribution by industry group and by waste stream are provided in Figures 1 and 2.



SQGs
(≥ 100 kg/mo)

VSQGs
(< 100 kg/mo)

FIGURE 1.
DISTRIBUTION OF SMALL QUANTITY GENERATORS
BY INDUSTRY GROUP: SQGs AND VSQGs

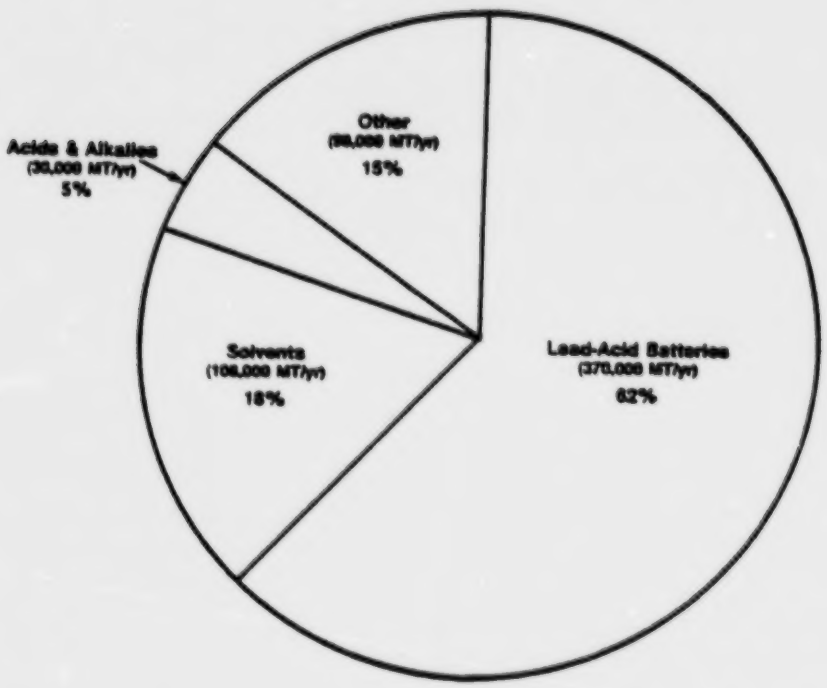


FIGURE 2
DISTRIBUTION OF SMALL QUANTITY GENERATOR
WASTE BY WASTE STREAM

B. Industry Segments Surveyed

As previously mentioned, earlier work conducted for the USEPA by Abt Associates resulted in the identification of business groupings and hazardous wastes for each group and served as the basis for the design of these surveys. All businesses with the potential to generate hazardous wastes were designated by their Standard Industrial Classification (SIC) number [SIC - a method utilized in the U.S. to identify various industrial segments. Established and maintained by the U.S. Department of Commerce]. The total array of businesses was aggregated into 24 segments of like businesses which could be expected to generate related types of hazardous wastes. The industry segments along with their associated SIC codes are listed in Table 1.

C. Waste Categories For Each Business Group

The potential hazardous wastes that were expected to be generated by the 24 business groups were listed in 27 categories. These categories were:

1. Arsenic wastes
2. Cyanide wastes
3. Dry cleaning filtration residues
4. Emtpy pesticide containers
5. Heavy metal dust
6. Heavy metal solutions
7. Heavy metal waste materials
8. Ignitable paint wastes
9. Ignitable wastes
10. Ink sludges containing chromium or lead
11. Mercury wastes
12. Other reactive wastes
13. Paint waste containing heavy metals
14. Pesticide solutions
15. Photographic wastes
16. Solvent still bottoms
17. Spent plating wastes
18. Spent solvents
19. Solutions or sludges containing silver
20. Strong acids or alkalis
21. Used lead-acid batteries
22. Waste formaldehyde
23. Waste inks containing flammable solvents or heavy metals
24. Waste pesticides
25. Wastewater sludges containing heavy metals
26. Wastewater containing wood preservatives
27. Wastes containing ammonia

D. Industry Listings

Using the Abt SIC numbers with some minor modification by GRCDA, commercial lists were purchased which covered the project area. These lists, with

TABLE 1

SIC CODES FOR INDUSTRY SEGMENTS

	Business Groups	Primary SIC Codes
1.	Pesticide-End Users	7992, 8421
2.	Pesticides-Cattle Dipping	0751
3.	Pesticides-Application Services	0711, 0721, 0729, 0782, 0783, 4959, 7342
4.	Chemical Manufacturing	2819, 282, 2861, 2869
5.	Wood Preserving	2491
6.	Formulators	2834, 2879, 2893, 2899
7.	Laundries	7216, 7217, 7218
8.	Other Services	726, 7349
9.	Photography	7332, 7333, 7395, 841
10.	Textile Manufacturing	223, 225, 226, 227
11.	Vehicle Maintenance	0722, 16, 1794, 421, 4469, 5237, 55, 7512 7513, 7519, 753
12.	Equipment Repair	461, 48, 5962, 762, 763, 7694, 7996
13.	Metal Manufacturing	2514, 2522, 2542, 335, 339, 34 (exc. 347, 3482, 3483, 3489), 347, 35, 36 (exc. 3691, 3692), 3714, 38 (exc. 3840, 3861), 3843, 3861, 391, 3961, 3964, 3993, 3995
14.	Construction	1711, 1721, 1743, 1752, 1761, 1793, 2451, 2452, 40
15.	Motor Freight Terminals	4231
16.	Furniture/Wood Manufacture and Refinishing	2434, 2435, 2436, 2492, 2511, 2517, 2519, 2521, 2541, 7641
17.	Heavy Metal Users	0724, 3211
18.	Printing/Ceramics	264, 265, 27, 3251, 3253, 326, 7312
19.	Cleaning Agents and Cosmetic Manufacturing	2841, 2842, 2843, 2844
20.	Other Manufacturing	3079, 31, 3291, 3293,
21.	Paper Industry	2611, 2621, 2631, 2661,
22.	Analytical and Clinical	7391, 7397, 8062, 8069, 8071, 8072, 822, 8922
23.	Educational and Vocational Shops	8211, 8249, 8331
24.	Wholesale and Retail Sales	516, 5191, 5198, 523, 525, 531

appropriate additions and deletions by the counties, formed the basis for the survey. Commercial lists were chosen due to their availability by SIC and jurisdiction as well as their relatively modest cost. Past experience by GRCDA had shown that commercial listings are reasonably up-to-date and comprehensive. Businesses that had moved or had disappeared were easily found during the survey.

Some new businesses were found by the jurisdictions while others were deleted since they had either left the area or gone out of business. The survey was intended to be comprehensive, but not exhaustive. It is estimated that over 95% of the specified establishments were included in the lists.

E. Survey Implementation

GRCDA provided the jurisdictions with survey forms to be used for telephone or on-site surveys. Survey forms were mailed by GRCDA to all listed businesses in Delaware and Virginia along with an invitation to a free seminar concerning the proposed regulations which would apply to persons generating between 100 and 100 kg/mo. Briefings for the generators were held in all study areas to provide businesses with information about hazardous wastes and the survey.

F. Survey Content

The survey forms listed the types of wastes which each particular industry segment would be expected to generate. The requested data included:

1. Types of hazardous waste generated
2. Quantity of wastes generated per month
3. Method of disposal for each waste
4. Any disposal problems encountered
5. Comments

Additional information including but not limited to name, address, phone number, SIC number, date contacted, etc. was also obtained whenever possible. These data are not utilized in this paper. Figure 3 is a sample of the type of survey form used.

G. Sample Size

The goal of the survey was to determine the current disposal practices of unregulated hazardous waste generators and to determine if these methods were acceptable to the local jurisdictions. In addition, an effort was made to define any indicated actions on the part of local government which could require and/or assist small businesses in the proper management of these wastes. The project was not intended to provide a base for the rigorous analysis of waste quantities.

Each industry segment was surveyed until it was intuitively determined that the disposal methods had been adequately defined. This means that businesses

Please check the appropriate spaces or fill in indicated blanks.

1. Do you already have a Generator ID#? Yes_____ ID#_____ No_____

2. What is the SIC Code for your business? (If known) _____

3. Do you get rid of any of the following items?

	Quantity/Mo. Specify Units
Empty pesticide containers	_____
Washing or rinsing solutions containing pesticides	_____
Waste pesticides	_____

4. Please list any other chemical you routinely buy which is not included in #3 above.

_____

_____

5. Who collects items listed in 3 & 4 above?
Agency or Company (name)?_____
How often collected?_____

6. Final disposition(s) of items listed under 3 & 4?
Name of disposal facility_____
Don't know_____

7. Is your business connected to public sewer? Yes_____ No_____

8. Are you aware of the new hazardous waste regulations for small quantity generators?

Yes_____ No_____ Need Information_____

9. Name of business:_____
Complete Address of business:_____
_____
Name of Contact Person:_____
Telephone No._____

FIGURE 3
PESTICIDE APPLICATORS
SMALL QUANTITY HAZARDOUS WASTE GENERATOR SURVEY
SMALL BUSINESS QUESTIONNAIRE
(GROUP 3)

like gasoline service stations which generate virtually identical wastes were sampled at a lower level than segments such as metal manufacturing which is highly variable from business to business. The data obtained from the surveys were consistent with data obtained from other sources and surveys. Therefore, it is felt that the results of this project are valid in terms of disposal methodology and types of wastes.

II. SURVEY RESULTS

A. Overview

In an effort of this nature with three very diverse geographical areas being surveyed by a variety of individuals it can be expected that a diversity of results will occur. In addition, the businesses being surveyed clearly varied in their sophistication. Further, there was never any intent to try to assure uniformity of effort in an attempt to develop statistically comparable data. This variance naturally resulted in wide ranges of estimation of types and quantities of hazardous waste being generated. The end result from this diversity is the fact that the data from the three areas is so variable that no statistical analysis can be conducted on the survey results.

Nevertheless, there is considerable interest in looking at the information from the three survey areas to see how the information compares and how the practices and perceptions of the surveyed universe vary, if at all, between the three geographical areas. The survey results clearly provide some significant insights into what must be done by business and government to get hazardous wastes out of municipal solid waste systems and into different waste management systems.

B. Presentation of Survey Data

Although 24 business segments were surveyed, eight were found to represent major sources of small quantities of hazardous wastes. Table 1 provides a complete listing of all business groups surveyed. Table 2 provides a listing of the eight segments considered to be the major contributors of small quantities of hazardous wastes.

Even in the eight major hazardous waste generating groups it was not possible to gather comparable data. Although all surveys gathered data on quantities, generation rates and practices in a comparable manner, the geographical diversity and the individual reactions and knowledge of each small business surveyed prevented statistically comparable data.

It became obvious early in the effort that the small businesses being surveyed had difficulty in identifying what was a hazardous waste. Although they

TABLE 2

BUSINESS SEGMENTS WITH MAJOR HAZARDOUS WASTE GENERATION

BUSINESS SEGMENT	SURVEY GROUP NUMBER	SIC CODES
Pesticide Applicators	3	0711,0721 0729,0782 0783,4959,7342
Photography	9	7332,7333,7395 8411
Vehicle Maintenance	11	0722,16,1794 431,4469,527 55,7512,7513 7519,753
Printing/Ceramics	18	264,265,27 3251,3253,326 7312
Laundries/Cleaners	7	7216,7217,7218
Metal Manufacturers	13	2514,2522,2542 335,339,34(exc 347,3482,3483 3489),347,35 36(exc 3691, 3692),3741,38 (exc3842,3861) 3843,391,3961 3964,3993,3995
Educational and Vocational Facilities	23	8211,8249,8331
Analytical and Chemical Laboratories	22	7391,7397,8062 8069,8071,8072 822,8922

all had received information about the types of materials that could be hazardous wastes (see Appendix A), the majority remained uncertain and most had not spent their resources on laboratory analytical services to aid in identification.

The problem of waste identification paled, however, in comparison to attempting to quantify the amounts of hazardous wastes being generated. In gathering the information through the phone surveys attempts were made to get the generators to identify how, and in what, they stored their wastes prior to disposal. Container sizes, trips to the storage containers, etc. were all discussed in an attempt to gain some insights into the amounts generated. The effort was further complicated by the fact that the wastes were in both liquid and solid form and no weighing or measuring of wastes generated were conducted by the generators. Consequently, in reducing the data for purposes of analysis and comparison it was necessary to make some assumptions on weight versus volumes in order to try to compare and report survey results.

Table 3 summarizes the survey results for five of the eight business groups listed in Table 2. Results for the other three business groups is not provided because of the wide variability of the results. Table 3 includes some discussion about these three business groups relative to their waste management practices.

Quantities have been converted to gallons and in the case of lead acid batteries the number of batteries discharged. In all instances the generation data is reported on a monthly basis since it is the calendar month which determines if a small quantity hazardous waste generator must meet the U.S. federal requirements. No quantification is provided for the survey effort in Virginia. In the Virginia effort three communities and two counties distributed throughout the state participated in the survey. In reviewing the data it was felt that such wide geographical distribution prevented the statistical integration of the data into one data set for the entire state. However, waste management practices were uniform enough to be presented.

Finally, some graphical illustrations from the Puget Sound survey are presented to illustrate the distribution of types of hazardous wastes by quantities from the reported business groups. It is believed that these figures are reflective of all areas surveyed.

TABLE 3
SURVEY RESULTS FROM FIVE SELECTED BUSINESS GROUPS

Business Group	Waste Type Survey Area	Amount Generated	Management Practices
Pesticide Applicators	Containers		
	DL	x	Landfill
	PS	x	Ground
	VA	x	Dumpsters
	Rinsing Solutions		
	DL	x	Makeup Solution
	PS	x	Ground
	VA	x	Ground
	Waste Pesticides		
	DL	x	Landfill
	PS	x	Landfill
	VA	x	Landfill
Photography	Photographic Wastes		
	DL	11GPM	Public Sewers
	PS	6GPM	Public Sewers Recycled
	VA	x	Public Sewers
	Silver Containing Wastes		
	DL	8GPM	Public Sewers
	PS	1GPM	Public Sewers
	VA	x	Public Sewers
Vehicle Maintennce	Ignitable Paint Wates		
	DL	46GPM	Hauler
	PS	2GPM	Hauler/Recycled
	VA	x	Hauler
	Spent Solvents		
	DL	42GPM	Hauler
	PS	16GPM	Hauler/Recycled
	VA	x	Hauler

	Other Ignitable Wastes		
	DL	60GPM	Hauler
	PS	2GPM	Hauler
	VA	x	Hauler
	Acid/Alkaline Wastes		
	DL	8GPM	Hauler
	PS	13GPM	Hauler
	VA	x	Hauler
	Lead Acid Batteries		
	DL	7/MO	Junked/Landfill
	PS	4/MO	Junked
	VA	x	Junked/Landfill
	Oil/Grease		
	DL	x	x
	PS	12GPM	x
	VA	x	Hauler
Printing Ceramics	Photographic Wastes		
	DL	25GPM	Public Sewer Landfill
	PS	7GPM	"
	VA	x	"
	Ink Sludges		
	DL	125GPM	Landfill
	PS	1GPM	"
	VA	x	"
Laundries	Filters		
	DL	x	Landfill
	PS	x	Landfill/Recycled
	VA	x	x
	Residues		
	DL	35GPM	Recycled
	PS	103GPM	Landfill
	VA	x	Recycled/Landfill

DL - Delaware Survey
PS - Pugent Sound Survey
VA - Virgnia Survey
GPM - Gallons per month

Types of hazardous wastes generated by the three business groups not included in the data in Table 3:

Metal Manufacturing - cyanide containing wastes, ignitable paint wastes, reactive wastes, solvent still bottoms, spent solvents, acid/alkaline wastes; haulers and public sewers were the identified means of management.

Educational and Vocational Facilities - the majority of facilities reported no wastes; the balance reported small quantities of oil/grease and spent solvents; recycling and haulers were the identified means of management.

Analytical and Chemical Laboratories - spent solvents, mercury wastes, solvent still bottoms, acid/alkaline wastes; public sewers and landfills were the identified means of management.

Some comments on how the data is reported is necessary in order to avoid misinterpretation:

1. Landfill - This clearly indicates that the hazardous waste is being disposed of in a non-hazardous waste disposal facility. Whether the businesses reporting are in violation of the new U.S. federal small quantity hazardous waste regulations will depend on the amount of wastes generated. This practice may be in violation, however, of local/state solid waste regulations.

2. Public Sewers - Whether this practice is in violation of the new U.S. federal regulations for small quantity hazardous waste generators would depend upon the quantities produced. In addition, these practices may be in violation of water pollution control regulations.

3. Dumpsters - This practice would imply that these wastes are not going to a hazardous waste management facility. Rather, the wastes are probably going to non-hazardous waste landfills. Whether the businesses utilizing this practice are in violation of U.S. federal small quantity hazardous waste regulations depends upon the quantities produced. This practice, however, may be in violation of local/state solid waaste regulations.

4. Hauler - This practice indicates that the hazardous wastes are being taken by a commercial hauler. The fate of these wastes were, for the most part, unknown by the businesses using this

service. The probable fate of the majority of these wastes are probably non-hazardous waste landfills. Some small portion is probably going to hazardous waste management facilities or are being recycled.

5. Junked - This term is used in the management of lead acid batteries. This practice could either imply recycling or storage at some automobile junkyard. The businesses reporting these practices were not aware of the ultimate fate of the lead acid batteries being generated.

C. Discussion

1. Pesticide Applicators. The survey showed that empty pesticide containers were probably being handled properly with virtually all respondents stating that the containers were triple rinsed before being placed in the municipal solid waste systems. In general, empty pesticide containers do not seem to be a major problem.

Proper procedure calls for container rinsate to be used as part of the pesticide solution. This procedure was generally followed; however, some businesses indicated that the rinsate was being dumped on the ground. Due to the very low concentrations involved, this practice probably represents little or no problem at the farm or home levels when done only occasionally. If this practice is followed by commercial applicators at one location, such rinsate disposal could create contamination in a local area.

Most waste pesticides in concentrated form are returned to the manufacturer. However, in some cases the manufacturer cannot or will not accept the material. In these cases waste pesticides must be handled by a RCRA permitted hazardous waste disposal facility. Due to cost or lack of knowledge, some applicators were storing waste pesticides on site. These situations represent a need for additional information on the part of the businesses.

Figure 4, from the Puget Sound survey results illustrates the distribution of wastes generated by pesticide applications services. It is interesting to note that approximately 50% report no wastes (hazardous).

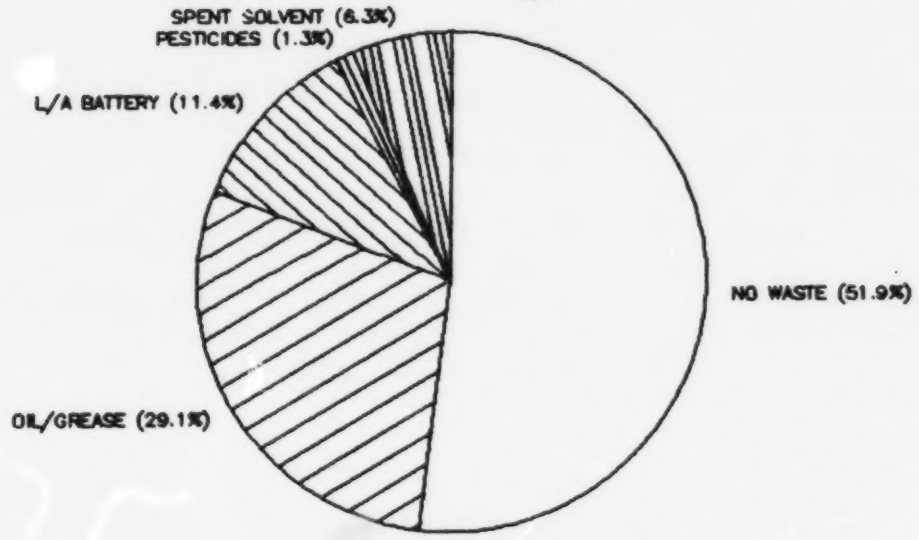


FIGURE 4
PESTICIDE APPLICATION SERVICES
GENERATED WASTES
(% OF QUANTITIES)

2. Photography. The results of the survey indicates that most businesses are probably below the 100 kg/mo level. However, discharges of wastes containing silver may be a problem. Figure 5, from the Puget Sound survey results, provides a pictoral distribution of the wastes generated.

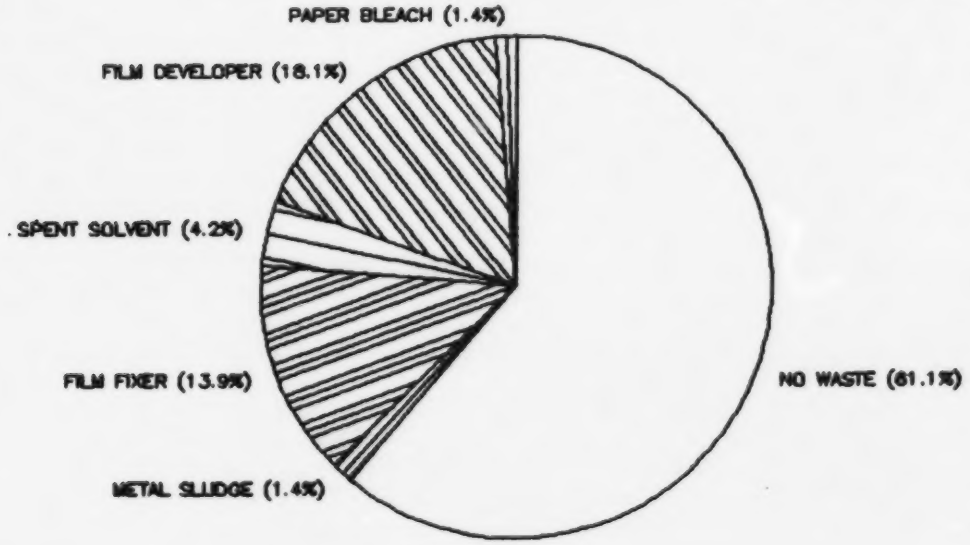


FIGURE 5
PHOTOGRAPHY SERVICES
GENERATED WASTES
(% OF QUANTITIES)

3. Vehicle Maintenance. This segment represents, by far, the largest of the potential hazardous waste generators both in numbers of businesses and quantity of waste generated. Spent solvents, waste oil, lead-acid batteries, and heavy metal dust constitute the major waste streams for this group. Waste oil is currently not regulated under RCRA. It is anticipated that waste oil will become regulated as a hazardous waste sometime during 1986.

Under RCRA regulations lead-acid batteries are also not regulated if they are being reclaimed or recycled. Heavy metal dusts may be either hazardous or non-hazardous depending upon the metals which make up the dust.

This segment has the potential to create significant pollution of the environment and/or contamination of the municipal solid waste system due to the types and quantities of wastes generated.

Wastes going to haulers and landfills have the potential to impact solid waste workers as well as the environment through the pollution of air, water, and ground.

Recycled wastes are probably handled properly for the most part; however, this fact was not verified under the scope of work for the surveys. The businesses which reported that their wastes were collected by a hauler for proper handling did not know the final disposition of the wastes. It is possible that some fraction of these wastes managed by a service or hauler may be disposed of improperly.

The survey results indicated a range of waste management practices from junking-recycling-landfilling for lead-acid batteries. Lead-acid batteries are becoming a major disposal problem due to a continuing decrease of businesses that will recycle them. Moreover, batteries from motorcycles and similar types of equipment are not reclaimed for metal content. It appears that the used lead market is such that the smelters have a more than adequate supply of scrap lead without bothering with the problems associated with handling lead-acid batteries. The surveys clearly indicate that in some areas retailers will not accept old batteries when a new one is purchased. The vehicle owner has to take the old battery home. It may be assumed that the homeowner usually disposes of the battery by putting it in the trash.

If reclamation becomes less available because reclaimers have to be permitted as a hazardous waste treatment facility a significant portion of

the batteries may be diverted to municipal solid waste systems. If this happens, a major difficulty will occur.

If and when waste oil is regulated as a hazardous waste, the vehicle maintenance industry should have little difficulty in properly managing the waste since there is an existing and viable service industry available. However, many oil reclaimers may also wind up being regulated as hazardous waste treatment facilities. Another issue that could emerge in those areas where local service stations accept waste oil from homeowners is that the station operator has no way of determining the content of the oil. There is reason to believe that waste oil could and would not be accepted from homeowners unless accompanied by a certified laboratory analysis. Since this requirement could not reasonably be met by individuals, their waste oil would logically be put in the trash, dumped on the ground or otherwise mismanaged.

Figure 6 from the Puget Sound survey provides an illustration of the distribution of hazardous wastes from vehicle maintenance enterprises.

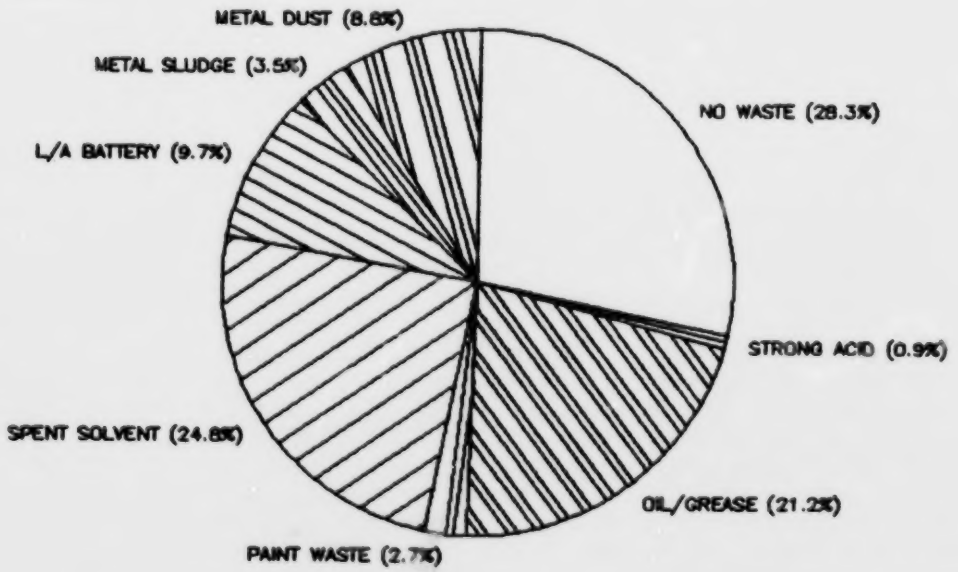


FIGURE 6
VEHICLE MAINTENANCE SERVICES
GENERATED WASTES
(% OF QUANTITIES)

4. Printing and Ceramics. The vast majority of the wastes generated by this segment come from the printing industry, due in large measure to the number of establishments represented. The wastes are similar in nature to those found in the photographic industry with the addition of ink wastes. The majority of these wastes are discharged to the public sewer systems. A significant fraction are disposed of via ground dumping and the municipal solid waste systems (landfill).

Figure 7, from the Puget Sound survey, provides an illustration of the distribution of hazardous waste from printing and ceramic enterprises.

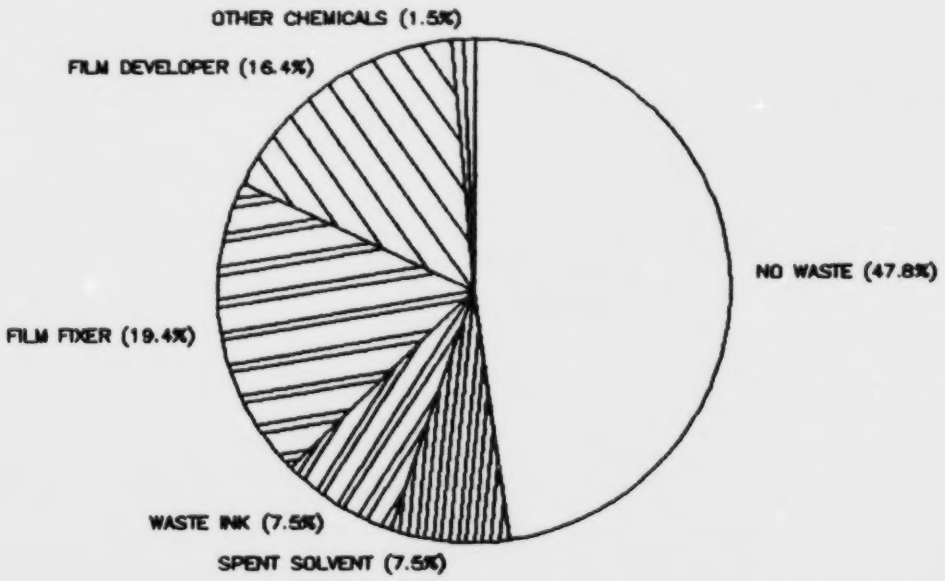


FIGURE 7

PRINTING AND CERAMIC SERVICES
GENERATED WASTES
(% OF QUANNTITIES)

5. Laundries and Cleaners. There were divergent practices between the Puget Souhd survey and the Delaware/Virginia surveys. Recycling was reported to be the major practice in the Puget Sound survey

while landfilling seemed to be the preferred options in the Delaware and Virginia areas.

Figure 8, from the Puget Sound survey, provides an illustration of the distribution of hazardous wastes from laundry and dry cleaning enterprises.

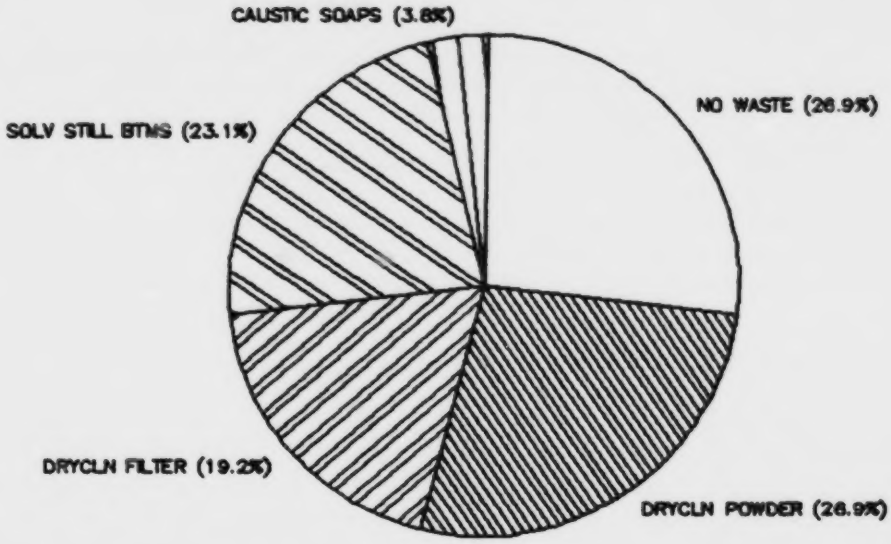


FIGURE 8

LAUNDRIES-DRY CLEANERS
GENERATED STATES
(% OF QUANTITIES)

III. CONCLUSIONS

In reviewing the data from the three survey efforts and attempting to compare the data it is evident that there are wide ranges of opinion on the part of small businesses relative to what is a hazardous waste and how much hazardous waste is generated. Certainly, if one is to believe the quantities reported the vast majority of businesses will fall beflow the 100 kg/month level which keeps these businesses out of a much more expensive waste management strategy. It would appear that as much as 90% of the small businesses fall below the 100 kg/month level.

One can ask several questions because of the wide range of generation rates and the dependence upon the businesses to determine their waste characteristics and quantities:

1. Do the small businesses really know what is a hazardous waste? Most of the businesses surveyed deal with chemicals on a day to day basis. They should know the degree of hazard associated with the products they handle. It seems reasonable to conclude that they do know that their wastes contain chemical substances which may represent a hazard to health and environmental quality. They may not be ready to recognize, however, that these wastes should not be mixed with non-hazardous waste products or disposed of in the same system that is handling municipal solid wastes. This is a reasonable reaction on their part, given the fact that they are following waste management procedures which have been in place for many decades. Further, they are probably not ready to accept the fact that they have to determine how much waste they are generating as the first step to placing their businesses into a new federal regulatory program.
2. Do the small businesses know, quantitatively how much waste they generate? It is unlikely that they do since they have never had to determine the weight of the waste they generate. While they may pay for a service based on the size of storage container used, the size and frequency of service for that container has little to do with the weight of solid wastes generated. For the most part, they depend upon who ever provides the service to determine the size of container and the frequency of service.
3. Do small businesses know what happens to their wastes once it is picked up? Except for such specialized services as solvent recovery and similar reclamation practices it appears that few of the businesses surveyed really know the ultimate fate of their wastes. As in the previous paragraph's discussion of quantification, they have never had to know in the past and even though there are new management requirements they still don't know.
4. Have haulers that provide solid waste management services to small businesses altered their practices because of the new U.S. federal small quantity hazardous waste regulations. Although the survey did not follow the management practices beyond the point of inquiring from the business if they knew where their wastes went, it is clear that waste management practices have not changed dramatically because of the new U.S. federal regulations. One can assume this to be the case since most businesses had not changed their solid waste management practices nor did they report any change in their practices nor any increase in costs for management.

5. Have the receiving disposal facilities modified their practices as a result of the new U.S. federal small quantity hazardous waste regulations? Obviously not, given their continued reported practices of disposal of wastes through public sewers and landfills. While the disposal of some of these wastes in the public sewers may be permitted it is obvious that no real determination has been made by most businesses relative to the legitimacy of this practice. The acceptance of these wastes at landfills is strictly a matter of quantities. If the generator falls below 100 kg/month the practice is legal and if it is over 100 kg/month it is not. Clearly, since the businesses report, for the most part, no change in practices, some number of municipal solid waste disposal facilities are receiving hazardous wastes illegally.

The surveys showed that there are significant quantities of hazardous or quasi-hazardous wastes generated by the surveyed businesses. Most of the businesses generate less than 100 kg/month if waste oil and lead-acid batteries are excluded. This means that the disposal practices will probably have to be monitored and regulated by local government agencies.

Vehicle maintenance is by far the largest segment both as to number of businesses and quantity of waste generated. Metal manufacturers and dry cleaners are next in order. A significant quantity of waste from these industries is mismanaged at the current time. If regulations for waste oil and lead-acid batteries become more stringent in the future, this may cause a significant portion of these wastes to be diverted illegally to the municipal solid waste systems.

The survey data show that there exists for the most part commercial businesses which are engaged in managing these wastes. However, the methods of disposal and/or other management methods are not known. It is impossible to determine the needs of the businesses which generate hazardous wastes until their businesses are required to manage their wastes in a proper fashion. Without regulation and enforcement, local governments will not be able to eliminate the use of dumpsters, sewers, and landfills because haulers, service companies, and generators will take the course of least resistance. Further, existing recycling and other "services" in terms of ultimate disposal as well as incineration in facilities designed for space heating may not be in compliance. In addition, experience has shown that commercial services tend to become either nonexistent or very expensive as one moves away from metropolitan areas.

It seems that local governments must continue to be involved in the management of these wastes in order to protect solid waste personnel during collection, transfer, and disposal and to protect the environment

and themselves against the potential long-term problems associated with the land disposal of these wastes.

Finally, it is clear that small businesses need considerable assistance in determing where they sit in the small quantity hazardous waste generator regulatory picture. Information and assistance on waste identification and quantification, proper management practices, and proper handling procedures are badly needed.

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APPENDIX A

TYPES OF HAZARDOUS WASTES THAT MIGHT BE GENERATED BY INDUSTRY GROUPINGS.

	(1) Pesticides-end Users	(2) Pesticides-Cattle dipping	(3) Pesticides-Application Services	(4) Chemical Manufacturing	(5) Wood Preserving	(6) Formulators
1. Arsenic wastes						
2. Chromium - containing dusts or sludges				X		X
3. Cyanide wastes						
4. Cyanide wastes (other than those from photographic processes)						
5. Dusts containing heavy metals				X		
6. Empty pesticide containers	X		X			X
7. Filtration residues from dry cleaning operations						
8. Ignitable paint wastes containing flammable solvents						
9. Ignitable wastes						
10. Ignitable wastes (other than ignitable paint wastes)						
11. Ignitable wastes (other than spent solvents)						
12. Ignitable wastes (other than spent solvents or ignitable paint wastes)						
13. Ignitable paint (other than spent solvents or solvent still bottoms)				X		X
14. Ignitable waste (other than spent solvents, solvent still bottoms or ignitable paint wastes)						
15. Liquid paint waste containing heavy metals						
16. Mercury containing wastes						
17. Photographic wastes						
18. Reactive wastes (other than acids/or alkalis)				X		
19. Reactive wastes (other than cyanides, acids or alkalis)				X		X
20. Sludges from ink formation containing chromium and lead						
21. Solutions or sludges containing silver from photographic processes						
22. Solvent still bottoms				X		X
23. Spent pesticide solutions and sludges other than toxaphene		X				
24. Spent plating wastes						
25. Spent solvents				X		X
26. Spent solvents (other than those in ignitable paint waste)						
27. Spent solvents (other than those in waste inks)						
28. Spent toxaphene solutions or sludges		X				
29. Strongly acidic or alkaline wastes				X		X
30. Strongly alkaline wastes						
31. Used lead-acid batteries						
32. Washing and rinsing solutions containing heavy metals						X
33. Washing and rinsing solutions containing pesticides	X		X			
34. Waste inks containing flammable solvents or heavy metals						
35. Waste materials containing heavy metals				X		X
36. Waste pesticides	X		X			
37. Wastes containing arsenic						
38. Wastes containing formaldehyde						
39. Wastewater treatment sludges containing heavy metals						
40. Wastewater treatment sludges containing pentachlorophenol, creosote, or arsenic					X	

TYPES OF HAZARDOUS WASTES THAT MIGHT BE GENERATED BY INDUSTRY GROUPINGS

	(7) Laundries	(8) Other Services	(9) Photography	(10) Textile Manufacturing	(11) Vehicle Maintenance	(12) Equipment Repair
1. Arsenic wastes						
2. Chromium - containing dusts or sludges						
3. Cyanide wastes						
4. Cyanide wastes (other than those from photographic processes)						
5. Dusts containing heavy metals						
6. Empty pesticide containers						
7. Filtration residues from dry cleaning operations	X					
8. Ignitable paint wastes containing flammable solvents			X		X	X
9. Ignitable wastes		X				
10. Ignitable wastes (other than ignitable paint wastes)						
11. Ignitable wastes (other than spent solvents)		X	X			X
12. Ignitable wastes (other than spent solvents or ignitable paint wastes)			X		X	X
13. Ignitable paint (other than spent solvents or solvent still bottoms)						
14. Ignitable waste (other than spent solvents, solvent still bottoms or ignitable paint wastes)						
15. Liquid paint waste containing heavy metals			X		X	X
16. Mercury containing wastes						
17. Photographic wastes			X			
18. Reactive wastes (other than acids/or alkalis)						
19. Reactive wastes (other than cyanides, acids or alkalis)						
20. Sludges from ink formation containing chromium and lead						
21. Solutions or sludges containing silver from photographic processes			X			
22. Solvent still bottoms				X		
23. Spent pesticide solutions and sludges other than toxaphene						
24. Spent plating wastes						
25. Spent solvents		X	X	X	X	X
26. Spent solvents (other than those in ignitable paint waste)			X		X	X
27. Spent solvents (other than those in waste inks)						
28. Spent toxaphene solutions or sludges						
29. Strongly acidic or alkaline wastes		X	X		X	X
30. Strongly alkaline wastes						
31. Used lead-acid batteries					X	
32. Washing and rinsing solutions containing heavy metals						
33. Washing and rinsing solutions containing pesticides						
34. Waste inks containing flammable solvents or heavy metals						
35. Waste materials containing heavy metals						
36. Waste pesticides						
37. Wastes containing ammonia		X				
38. Wastes containing formaldehyde		X				
39. Wastewater treatment sludges containing heavy metal						
40. Wastewater treatment sludges containing pentachlorophenol, creosote, or arsenic						

TYPES OF HAZARDOUS WASTES THAT MIGHT BE GENERATED BY INDUSTRY GROUPINGS

	(13) Metal Manufacturing	(14) Construction	(15) Motor Freight Terminals	(16) Furniture/Wood Manufacture and Refinish	(17) Heavy Metal Users	(18) Printing/ Ceramics
1. Arsenic wastes					X	
2. Chromium - containing dusts or sludges	X					
3. Cyanide wastes						X
4. Cyanide wastes (other than those from photographic processes)					X	
5. Dusts containing heavy metals						
6. Empty pesticide containers						
7. Filtration residues from dry cleaning operations	X	X	X	X		X
8. Ignitable paint wastes containing flammable solvents		X			X	
9. Ignitable wastes						
10. Ignitable wastes (other than ignitable paint wastes)		X		X		
11. Ignitable wastes (other than spent solvents)		X		X		X
12. Ignitable wastes (other than spent solvents or ignitable paint wastes)	X					
13. Ignitable paint (other than spent solvents or solvent still bottoms)		X		X		
14. Ignitable waste (other than spent solvents, solvent still bottoms or ignitable paint wastes)	X	X	X			X
15. Liquid paint waste containing heavy metals					X	
16. Mercury containing wastes						X
17. Photographic wastes						
18. Reactive wastes (other than acids/or alkalis)	X					
19. Reactive wastes (other than cyanides, acids or alkalis)						X
20. Sludges from ink formation containing chromium and lead						
21. Solutions or sludges containing silver from photographic processes	X	X		X		
22. Solvent still bottoms						
23. Spent pesticide solutions and sludges other than toxaphene	X					X
24. Spent plating wastes	X	X		X		X
25. Spent solvents	X	X	X	X		X
26. Spent solvents (other than those in ignitable paint waste)						X
27. Spent solvents (other than those in waste inks)						
28. Spent toxaphene solutions or sludges	X	X	X			X
29. Strongly acidic or alkaline wastes						
30. Strongly alkaline wastes			X			
31. Used lead-acid batteries						
32. Washing and rinsing solutions containing heavy metals						
33. Washing and rinsing solutions containing pesticides						X
34. Waste inks containing flammable solvents or heavy metals						
35. Waste materials containing heavy metals						
36. Waste pesticides						
37. Wastes containing ammonia						
38. Wastes containing formaldehyde	X					
39. Wastewater treatment sludges containing heavy metal						
40. Wastewater treatment sludges containing pentachlorophenol, creosote, or arsenic						

TYPES OF HAZARDOUS WASTES THAT MIGHT BE GENERATED BY INDUSTRY GROUPINGS

	(19) Cleaning Agent and Cosmetic Manufacturing	(20) Other Manufacturing	(21) Paper Industry	(22) Analytical and Clinical Labs	(23) Educational & Vocational Shops	(24) Wholesale and Retail Sales
1. Arsenic wastes	X					
2. Chromium - containing dusts or sludges						
3. Cyanide wastes						
4. Cyanide wastes (other than those from photographic processes)						
5. Dusts containing heavy metals	X					
6. Empty pesticide containers						
7. Filtration residues from dry cleaning operations						
8. Ignitable paint wastes containing flammable solvents				X	X	X
9. Ignitable wastes		X				
10. Ignitable wastes (other than ignitable paint wastes)						X
11. Ignitable wastes (other than spent solvents)	X	X		X		X
12. Ignitable wastes (other than spent solvents or ignitable paint wastes)				X	X	X
13. Ignitable paint (other than spent solvents or solvent still bottoms)	X	X	X			
14. Ignitable waste (other than spent solvents, solvent still bottoms or ignitable paint wastes)						
15. Liquid paint waste containing heavy metals						
16. Mercury containing wastes				X		
17. Photographic wastes						
18. Reactive wastes (other than acids/or alkalis)				X	X	X
19. Reactive wastes (other than cyanides, acids or alkalis)						
20. Sludges from ink formation containing chromium and lead						
21. Solutions or sludges containing silver from photographic processes						
22. Solvent still bottoms	X	X	X			
23. Spent pesticide solutions and sludges other than toxaphene						
24. Spent plating wastes						
25. Spent solvents	X	X	X	X		X
26. Spent solvents (other than those in ignitable paint waste)				X	X	X
27. Spent solvents (other than those in waste inks)						
28. Spent toxaphene solutions or sludges						
29. Strongly acidic or alkaline wastes	X		X	X	X	X
30. Strongly alkaline wastes						
31. Used lead-acid batteries						
32. Washing and rinsing solutions containing heavy metals						
33. Washing and rinsing solutions containing pesticides	X					
34. Waste inks containing flammable solvents or heavy metals						
35. Waste materials containing heavy metals		X				
36. Waste pesticides						X
37. Wastes containing ammonia						
38. Wastes containing formaldehyde						
39. Wastewater treatment sludges containing heavy metal						
40. Wastewater treatment sludges containing pentachlorophenol, creosote, or arsenic						

Environmental Impairment Liability Insurance - An Alternative Approach

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As a result of the publicity given in recent months to problems besetting the insurance industry, few people can be ignorant of the difficulties encountered by both the public and private sectors of our economy in obtaining liability insurance in the amounts and at costs to which they have become accustomed. While Environmental Impairment Liability Insurance is relatively new in its concept, it has not been immune to the crisis in the liability market, and indeed may well have suffered more drastically than some of the other lines. The market for this type of insurance is now severely restricted, the limits available have been considerably reduced, and the cost has escalated. In addition, insurers are now exercising considerably more caution in the type of risks they are prepared to accept, and more information concerning acceptable risks is being demanded.

While further deterioration in current conditions in the liability insurance market may be avoided, it appears unlikely that any marked improvements can be expected in the immediate future. We may well then ask, what action can be taken, in light of the problems and expense associated with environmental impairment liability insurance, to minimize the potential for incidents and consequential exposure to claims which could jeopardize the financial integrity of our operations?

This type of exposure is by no means new, although the extent and nature of the liabilities associated with them may, in some jurisdictions, have been the subject of definition and delineation in recent legislation. In seeking solutions to our current problem, it would therefore appear appropriate to examine how these liabilities were handled in the past, how insurers reacted to changing circumstances, and how past experience and practices may be utilized to our best advantage.

Historically, Comprehensive General Liability Insurance Policies did not contain an environmental exclusion, and thus provided the cover considered appropriate for Environmental Impairment Liability. However, public awareness and concern resulted in an increase in the frequency with which parties resorted to the courts to obtain redress for damages suffered, or allegedly suffered, as a result of environmental impairment. The nature and extent of the court awards, recoverable in many instances under C.G.L.Policies, resulted in a serious re-assessment by insurers of the extent and nature of the environmental cover they were prepared to provide under such policies. Subsequently, in the early 1970's, an exclusion started to appear in C.G.L.Policies which effectively limited environmental cover to damages resulting from sudden and accidental occurrences.

These developments prompted some insurers to make available Environmental Impairment Liability Insurance. This cover was designed specifically to fill the gap generated by the exclusion

in the C.G.L.Policies and, at the same time, to provide as broad a cover as practical. Recognizing the wide variety and diverse nature of risks expected to be covered by such insurance, it is hardly surprising that insurers required, and still do require, that each risk be the subject of an engineering inspection and report, referred to by some as an Environmental Risks Analysis Report. While it was, in the past, possible to bind insurance prior to this inspection for certain classes of risk, this is no longer an accepted practice. Thus, the Risks Analysis Report has become an even more important factor in the consideration of the insurability of specific risks and in the determination of conditions of insurance.

In light of the importance attached by insurers to the Environmental Risks Analysis Process, and the Reports produced, it would not seem inappropriate to review the procedures involved and to examine how these might be applied in the context of our current considerations. In this connection it is worthy of note that the process has been proved to be a valuable tool for risk management and loss control, and is being used as a first step in Environmental Audit Programs.

The Environmental Risks Analysis Process has, as its initial and prime objective, the provision to insurance underwriters of an independent appraisal of the environmental exposures associated with the subject operations to permit the establishment of conditions of insurance. Components of this Primary Objective are as follows:-

A. Establish the risk of an environmental incident.
B. Assess the possible extent and nature of the environmental damage that could result from such an incident.
C. Assess the potential for claims from third parties.
D. Assess the nature, extent and financial impact of clean-up that could be involved.

Four Basic Elements are examined during the course of the process:-

1. Functional Factors
   (a) nature of the activities or operations
   (b) raw materials, process and products involved
   (c) liquid, solid and gaseous wastes generated

2. Operational Factors
   (a) corporate attitude towards loss control and environmental protection
   (b) local management attitude and response to corporate policies and regulatory requirements
   (c) loss control facilities
   (d) emission control and waste disposal facilities
   (e) emergency measures organization
   (f) compliance with regulatory requirements

3. Locational Factors
   (a) nature of the local environment
   (b) potential effects of steady state emissions on local environment
   (c) potential effect of acute discharges on local environment
   (d) activities of pressure groups in the area
   (e) activity of regulatory agencies
   (f) exposure to damage from seismic disturbances or other natural phenomena

4. Historical Factors
   (a) prosecutions for non-compliance with regulatory requirements
   (b) third party claims for injury, damage or nuisance
   (c) environmental incidents
   (d) past operations on the specific site and in the general area

The Risks Analysis Process, as outlined above, is by no means as comprehensive as an Environmental Audit, or as the Environmental Impact Statements required in many jurisdictions. However, it can be used to obtain a broad picture of the external environmental exposures associated with an operation, pinpoint areas of immediate concern, and identify those areas worthy of more detailed study. Thus it can be used to identify areas of weakness or those where more detailed investigation is warranted, and to implement the three very general courses of action set out below which are essential first steps in risk management and loss control:-

I. Identify any areas of weakness or potential weakness and take appropriate action to minimize the potential for incidents.

II. Develop spill containment, clean-up and emergency measures procedures and train necessary response teams.

III. Through in-house publications or information programs, forcefully communicate to all levels of staff and employees the importance of loss control and environmental protection.

With these general courses of action implemented, it will then be necessary to make as realistic an assessment as possible of the potential remaining for an environmental incident and the possible costs that would be entailed. If these are considered to be acceptable within the financial resources of the organization, then it is questionable whether insurance is a necessity under current conditions in the marketplace except to provide catastrophe insurance with a very high deductible. If however these

potential costs could put at risk the financial integrity of the organization, then further consideration must be given to insurance with as high a deductible as can be realistically assumed.

It is recognized that a process as outlined above cannot be accomplished without cost, whether it is undertaken using in-house resources or external consultants. However, any such costs should be weighed against the benefits that can accrue aside from the liability and insurance aspects. Many of the discharges and emissions that are the source of potential environmental problems comprise or contain raw materials, process liquids or products to which a real cost can be assigned. Thus, any action taken to eliminate or reduce such emissions or discharges must produce a saving to a greater or lesser degree. Similarly, any reduction in the quantities of such materials in steady state discharges will ameliorate problems associated with the treatment and disposal of these wastes.

In summary, under current conditions in the insurance marketplace, it would seem most prudent to take every practical measure to reduce environmental exposures and thereby eliminate or minimize the reliance placed on insurance for financial protection. This should not only improve the current position of an organization and place it in a much better position to obtain insurance under the most favorable conditions as and when such insurance becomes more readily available, but also assist in achieving regulatory requirements with respect to emission control and environmental protection.

TRANSFRONTIER ASPECTS OF HAZARDOUS WASTE MANAGEMENT

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For several decades now, the world has been undergoing a chemical revolution. As industry has expanded, approximately 70,000 new substances have been produced and put on the market and their numbers increase every year. (1) Chemicals are used in every facet of our work and home environments and have done much to increase health and living standards. Yet chemicals have also brought new dangers. Environmental contamination can result, either from direct misuse of chemicals or from mismanagement of their residues or wastes.

International concern about the possible environmental effects from the use and disposal of chemicals was first raised at the United Nations Conference on the Human Environment, held in Stockholm in 1972. Since that time, a succession of incidents world-wide, where people have been affected by toxic chemicals in food, water and the environment (1) gave credence to that concern and initiated the development of laws controlling the life cycle management of chemicals in most developed countries. Disposal of toxic chemicals is an important part of the life cycle management of chemicals.

Laws regulating the disposal of hazardous wastes are now in effect in most developed countries. Ongoing efforts are ensuring they are enforced in a cost-effective and environmentally sound way. More recently the international community has focussed its attention on the need for adequate controls of transfrontier shipments of hazardous wastes. "Transfrontier shipments" refers to consignments moved between countries.

As controls have tightened within developed countries the costs of hazardous waste management have increased. The degree of control exercised over hazardous waste disposal and disposal practices in many developed countries varies. These differences are even greater between the developed and developing countries. These differences create economic effects which can potentially influence some industries to relocate their operations to less stringently regulated countries or to export their wastes to countries where laws are less strictly enforced or to countries which may not be equipped to handle such wastes in an environmentally sound manner.

Hazardous wastes can easily cross borders, and indeed this practice should not be discouraged as long as wastes are handled in a manner which is cost effective and environmentally sound. However, since differences in controls exist and the existing systems for hazardous waste identification vary substantially, it is very important to ensure adequate controls over exports and imports of hazardous wastes are in place.

Several cases of wastes abandoned during transfrontier transport, the dioxin containing wastes from the Sevesno incident being the most widely publisized, clearly demonstrated the need to develop international procedures for transfrontier shipments.

The 1972 Declaration of the United Nations resulted from the Conference on the Human Environment, held in Stockholm. Principle 21 of the Declaration asserts that States have, consistent with the sovereign right to exploit their own resources pusuant to their own environmental policies, the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.

In keeping with this Principle, major international organizations such as the United Nations Environment Program (UNEP), the European Economic Community (EEC), and the Organization for Economic Cooperation and Development (OECD) have all initiated discussions on transfrontier controls for hazardous wastes.

Certain principles are common to all of the above organizations, and countries have cooperatively and voluntarily established practices which facilitate the control of transboundary movements of hazardous wastes.

The principles developed in the UNEP's "Guidelines for the Environmentally Sound Management of Hazardous Wastes", in the EEC's "Directive on the Supervision and Control of Tranfrontier Shipments of Hazardous Wastes within the European Community "(84/631/EEC), or in the OECD's February 1st, 1984 "Decision and Recommendation of the Council on Transfrontier Movements of Hazardous Wastes" (C(83)180(Final)) can be summarized as follows:

1. Each country agrees that the disposal of hazardous waste should be conducted in a way that the danger to public health, property, and environmental quality is minimized;

2. Each country will adequately manage wastes within the limits of their jurisdiction whether intended for export or not;

3. The exporting country will arrange for prenotification or transit and importing countries, consisting of timely and adequate information;

4. Each country agrees that wastes should not be exported without the consent of the importing country and consent of the transit country; and

5. The exporting country agrees to re-import wastes should the importing country's facility refuse to accept the shipment.

Consistent with the above principles, combined prenotification and manifest systems to implement effective controls are being developed, particularily in the European Community and OECD forums. Canada is an active participant and contributor to many of these initiatives, and endorses the aforementioned principles.

The European Economic Community has recently introduced a prenotification form which is to be used for transfrontier shipments between its member countries. The form contains information on all parties involved in the transborder transaction and a detailed description of the waste, its type, quantity shipped and packaging requirement. Required as well are certifications by the waste generator or party acting on his behalf, the waste hauler and the consignee or receiver of the wastes that they have each fulfilled their responsibilities in complying with regulations governing the transaction. An important feature of this prenotification form is the requirement that the explicit consent of the competent authority of the importing country be acknowledged before a shipment can proceed.

Perhaps the most active involvement to date concerning international cooperation in the transfrontier aspect of hazardous waste management can be illustrated by the ongoing work of the Waste Management Policy Group of OECD.

The most recent work of the Waste Management Policy Group has been related to the implementation of the resolutions resulting from the 1985 Basel, Switzerland Conference which are documented in "The Resolution of the Council of 20th June 1985 on International Cooperation Concerning Transfrontier Movements of Hazardous Wastes" (C(85)(100).

The main Basel resolutions called for an international system, of a legally binding character, for effective control of transfrontier movements and an effective system to control exports of wastes to non-OECD member countries.

Through an OECD Expert Group in Transfrontier Movements of Hazardous Wastes, Canada participated in the development of Principles and Recommendations on Exports of Hazardous Wastes from the OECD Area. I will first describe the considerations involved and the resulting principles contained in the "Decision and Recommendation of the Council of 5th June 1986 on Exports of Hazardous Wastes from the OECD Area" (C(86)64(Final)).

Bearing in mind the goal of improving environmental protection in all countries and the Basel Resolution that competent authorities should permit waste exports only to adequate disposal facilities and given that export of hazardous wastes may, if not properly monitored and controlled, result in serious risks to health and the environment, decisions and recommendations were put forward and approved as the mechanisms to control exports of hazardous wastes from the OECD area to non-OECD member countries.

The following decisions and recommendations are implemented through requirements placed on the exporter, and the requirements of the competent authorities of the exporting country to ensure that all responsibilities of have been met.

The following is a summary of the recommendations regarding exports to non-OECD Member countries:

Member countries shall:

i) Monitor and control exports of hazardous wastes to a final destination which is outside the jurisdiction of any Member country; and for this purpose shall ensure that their competent authorities are empowered to prohibit such exports in appropriate instances;

ii) Apply no less strict controls on transfrontier movements of hazardous wastes involving non-Member countries than they would for movements involving only Member countries;

iii) Prohibit movements of hazardous wastes to a non-Member country without the consent of that country and the prior notification of the proposed movements to any transit countries.

iv) Prohibit movements of hazardous wastes to a non-Member country unless the wastes are directed to an adequate disposal facility in that country.

In addition, member countries in implementing these decisions should:

i) Seek to conclude bilateral or multilateral agreements with non-Member countries to which frequent exports of hazardous wastes are taking place or are foreseen to take place;

ii) Apply the measures set out below (ie. controls on exporters) concerning exports of hazardous wastes to a final destination outside the jurisdiction of any Member country.

Parties to OECD have long been convinced that the implementation of effective controls for tansfrontier movements required the development of a system to clearly identify wastes which should be subject to such controls. Accordingly, extensive work to create an internationally agreed upon system of definitions, criteria and lists of hazardous wastes has progressed to the stage of a draft Council Decision.

The waste identification system has been developed using existing definitions and criteria for currently regulated hazardous substances where possible, and by seeking as much compatibility with other recognized criteria and lists for describing additional hazardous characteristics peculiar to hazardous wastes.

Recent proposed regulations in both the United States, under the Export/ Import Proposed Rulemaking under RCRA, and in Canada under existing Transportion of Dangerous Goods Regulations will ensure that the OECD Principles are enacted in respective North American legislation.

Technical discussions are underway between the U.S. EPA and Environment Canada officals to develop the basis for a bilateral agreement on transboundary shipments of hazardous wastes. The movement of hazardous wastes between the U.S. and Canada represents legitimate trade and reflects the fact that the two countries are close trading partners and share a long border. There are both economic and environmental benefits which accrue from a waste generator's ability to use the nearest appropriate disposal facility for the safe destruction of hazardous wastes. It is expected that the Canada/U.S. Memorandum of Understanding Regulating the Export and Import of Hazardous Wastes for Disposal will be signed this fall.

I leave the international forum and discuss the efforts being made in Canada to establish national uniformity for notification, manifesting and especially identification of hazardous wastes.

I will take a few moments first to outline the prenotification and manifest requirements.

The Transportation of Dangerous Goods Regulations stipulate that any intent to import or export hazardous wastes must be declared to Transport Canada and Environment Canada, in writing, at least 60 days before shipping wastes, giving detailed information about the waste consignment or series of consignments. The prenotification is used to notify a particular country or province of the arrival of hazardous wastes so they can take any verification or precautionary measures they may feel are necessary.

The type of information that the generator/consignor of the waste has to provide in the pre-notification letter includes the following:

- the name and address of the generator/consignor;
- the name, address, and telephone number of the consignee;
- the name and address of the carrier;
- the means of transport to be used;
- the description of the waste (including classification and product identification # and the method of packing);
- the date of the consignment or the approximate dates for each consignment in a series of consignments;
- name of every country and province the waste is to be transported through;
- the Customs office(s) the waste will be transported through (entry or exit point);
- a statement confirming that arrangements have been made to receive and treat or dispose of the waste;
- for PCB's, the generator must notify again, at least 7 days before each subsequent consignment is to be imported or exported.

There are two key areas covered by the federal regulations, the hazardous waste identification process, whch I will describe later, and the second area being the "cradle to grave" tracking of hazardous wastes from their point of generation to their ultimate disposal destination. The tracking control is accomplished via the manifest system. Under Part IV of the Regulations, all consignments of hazardous wastes must be accompanied by a waste manifest when they are shipped off-site from their place of generation to a disposal facility

The waste manifest, when completed, contains information about the shipment including:

- detailed information about the types and amounts of hazardous wastes being shipped;
- a record of the firms or individuals involved in the shipment (generator/consignor, carrier and consignee), and;
- information on the treatment, storage or disposal of hazardous wastes when they reach their final destination.

The manifest is a six-copy form. Each of the parties involved in transport and handling of a waste is responsible for completing part of the manifest and for distributing the individual copies of the manifest to the appropriate regulatory agencies. Copies of the manifest must be retained by all parties for two years after the hazardous wastes have reached their destination. The waste manifest thus provides a permanent record of the complete transaction for every shipment of hazardous wastes. The manifest also provides the vital link between the hazardous waste regulatory provincial legislations controlling the storage, treatment and/or disposal requirements at the receiving facilities. Copies of the uniform manifest are available from provincial regulatory agencies.

Indeed, most of these same concerns and needs have also provided the impetus in Canada, throughout the past six years of cooperative efforts of both the federal and provincial governments in consultation with all major industrial association, first, to establish transboundary controls for hazardous wastes and, second, to continue the development of uniformity of hazardous waste controls within individual provincial jurisdiction as well.

Particular focus has been made in Canada, on the need for uniformity in hazardous waste identification, including waste definitions, criteria and lists of waste contaminants or industrial wastes. Early-on it was decided that the waste identification system should incorporate existing criteria from other regulatory schemes for hazardous substances and add to those existing criteria and lists the necessary additional criteria required to describe the environmental effects posed by hazardous wastes.

These are the principles currently embodied in the Transportation of Dangerous Goods Regulations which became effective July 1, 1985. Thus the system for transboundary controls has been implemented.

At the present time, four of the ten provinces have complete hazardous waste management legislation governing the identification, manifesting, handling and disposal aspects of hazardous waste control. The remainder of the provinces have adopted the identification and manifesting provisions of the TDG Regulations and couple these provisions with the existing waste management legislation. Copies of the 'Users Guide to Hazardous Waste Classification' and the 'Users Guide for the Hazardous Waste Manifest' are available from Environment Canada, Industrial Programs Branch, Ottawa or the Regional offices of Conservation and Protection.

For the most part, the provincial systems are complementary to the national system, however there are still differences, especially in hazardous waste identification that we are continuing to resolve. All provinces agree that the ultimate goal is to refine the existing and proposed system, and attain one nation-wide system which will effectively address all hazardous waste movements.

Presently, the work of the federal/provincial committees under the Canadian Council of Resource and Environment Ministers is concentrating on the resolution of the problems of hazardous waste definition. This involves reaching consensus on the means to rectify the existing differences plus refining the current federal regulations dealing with hazardous waste to better address the needs of hazardous waste managment such that the concerns of individual provinces are adequately covered. Our consultative and cooperative process has to date, achieved uniformity regarding manifesting, achieved an identification process which soon should be a truly nation-wide system and has progressed towards the goal of uniformity in management standards.

The Regulatory Implications of Waste Oil Analysis

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OceanChem Limited

ABSTRACT

The use of waste oil as an inexpensive, readily available source of heating fuel is common in many commercial operations. Waste oil is produced by a multitude of industrial operations such as automobile service stations, machine shops, etc. In addition to the full range of hydrocarbons, waste oils may also contain waste chlorinated solvents resulting from de-greasing or cleaning operations. They have also been shown to contain PCBs resulting from either indavertent or deliberate mixing with PCB contaminated oil. Waste oil is a challenge to both the analyst, who is required to characterize the material and the regulatory agency who must establish guidelines and assess the environmental impact of its use. In some cases, the data obtained may be used in litigation thus necessitating the use of approriate chain-of-custody protocols in sampling and analysis.

This paper will discuss all aspects of waste oil analysis, from correct sampling procedures, the choice and use of appropriate analytical methodologies, quality control/quality assurance procedures, chain-of-custody considerations and data reporting. Data will be presented showing the result of the choice of analytical methodology not specific to waste oil, and the potential regulatory impact of this data. Existing Canadian guidelines will be compared to both American and European limits.

INTRODUCTION

Over the past several years, there has been an increasing public awareness of the potential environmental risk posed by the use of a wide variety of hazardous and toxic substances. Accidents such as occurred in Mississauga, Ontario, have done little to reassure the public that hazardous materials are being safely handled and transported.

The passage of the Transportation of Dangerous Goods Act, and subsequent Transportation of Dangerous Goods Regulations in 1985, greatly increased the regulatory powers as relates to the movement of potentially dangerous materials. These regulations which are intended to promote public safety during the transportation of dangerous materials, cover all modes of transport. and provides for the classification, documentation, safety labelling, reporting, notification, and training, as relates to all dangerous goods, including waste materials.

Among the great variety of commercial and industrial chemicals and other substances that are routinely transported across Provincial boundaries, is an increasing number of shipments of used or waste petroleum hydrocarbons and related material. These waste oil products are produced as a results of a variety of commercial operations and are typically collected by companies that are specifically in the waste oil business. Waste oil sources include automotive service stations, primary industries (fishing, farming,) and numerous commercial and manufacturing activities such as paint shops, metal plating operations, etc. It is estimated that the annual Canadian production of waste oil is in excess of 360 million litres, with less than 20 million litres being recovered and re-refined (Skinner et al., 1976). A schematic illustration of the production, collection, distribution, use and potential environmental impacts of waste oil is shown in Figure 1.

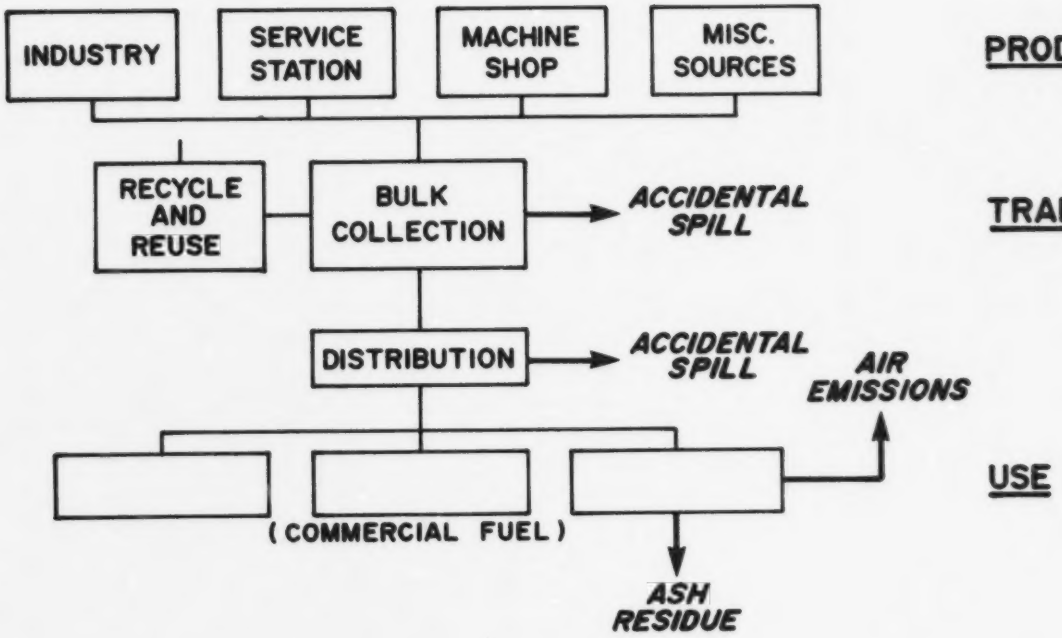
INDUSTRY
SERVICE STATION
MACHINE SHOP
MISC. SOURCES
PRODUCTION
RECYCLE AND REUSE
BULK COLLECTION
ACCIDENTAL SPILL
TRANSPORTATION
DISTRIBUTION
ACCIDENTAL SPILL
AIR EMISSIONS
USE
(COMMERCIAL FUEL)
ASH RESIDUE

FIGURE 1

In addition to a range of "normal" hydrocarbons, waste oils any also contain numerous other contaminants, such as:

- chlorinated hydrocarbon solvents, (e.g, perchlorethylene);
- non chlorinated solvents (e.g., acetone, varsol, etc.);
- polychlorinated biphenlys, (PCBs);
- miscellaneous substances, (extenders, plasticizers, grease, etc).

Waste crankcase oils also contain relatively high levels of certain trace metals such as lead, arsenic, manganese, etc.

As a result of both the variety and potential complexity of waste oil composition, the regulatory agency is faced with a highly complex management challenge, and must have complete confidence in the analytical data furnished by the analytical laboratory.

SAMPLE HANDLING PROTOCOLS

All sampling should be conducted with the possibility that at some future stage, legal proceedings may be necessary. Thus samples must be collected and transported using proper chain-of-custody protocols. All transfers of samples must be appropriately documented, signed, and witnessed, with copies of the documents retained by all parties involved. Samples must be collected in appropriately prepared containers, certified by the analytical laboratory to be clean and free of any traces of contaminants under analysis. Samples must be transferred to the laboratory as soon as possible and must be stored under appropriate conditions in a secure, locked facility.

ANALYTICAL PROTOCOLS AND RESULTS

INORGANICS

Waste oil samples may be analyzed for major and minor trace metals using any combination of the following methods.

- Inductively Coupled Plasma Emission Spectroscopy (ICP).
- Flame Atomic Absorption Spectroscopy (FAA)
- Graphite Furnace Atomic Absorption Spectroscopy (GFAA).

Waste oils may be analyzed directly by both ICP and FAA methods, however, some sample reparation is necessary if the contaminants are present at levels below the detection limits for these two methods thus necessitating the use of graphite furnace atomic absorption spectroscopy.

Table 1 illustrates typical major and minor trace metal values which have been observed in waste oil samples (U.S. EPA 1983).

TABLE 1
TYPICAL LEVELS OF MAJOR AND MINOR TRACE METALS IN WASTE OILS

Contaminant	Concentration (mg/kg)	
	Average	Range
Aluminum	45	< 1 - 640
Arsenic	12	< 1 - 100
Barium	66	10 - 160
Cadmium	1	< 1 - 2.8
Chromium	6	< 1 - 37
Iron	240	60 - 980
Lead	1100	350 - 2060
Magnesium	260	5 - 590
Vanadium	3	< 1 - 13
Zinc	800	90 - 1550

As can be seen, trace metal concentrations in waste oils can cover a wide range of concentrations.

Currently the province of Quebec has set maximum allowable concentrations for several contaminants that can be burned in waste oil. Table 2 lists these values.

TABLE 2
MAXIMUM ALLOWABLE CONCENTRATIONS OF SELECTION CONTAMINANTS IN WASTE OILS TO BE USED AS FUEL IN THE PROVINCE OF QUEBEC.

Contaminant	Maximum Allowable Concentration
Arsenic	5 mg/kg
Cadmium	2 mg/kg
Chromium	10 mg/kg
Lead	100 mg/kg
Zinc	5 mg/kg
PCB	0.15 mg/kg
Total Halogens	1500 mg/kg
Flash Point	38 °C

ORGANICS

There is often more concern for the potential presence of certain classes of organic compounds in waste oil products, therefore the choice of appropriate analytical procedures, specific to the contaminant, or class of contaminants of interest, becomes more important. The method chosen must be accurate, specific, precise, and reproduceable.

A major concern, is the presence of organochlorine substances such as chlorinated hydrocarbon solvents, and polychlorinated biphenyls (PCBs). This concern is a results of the potential transformation of these substances, under conditions of incomplete combustion to the more toxic materials; tetrachlorodibenzodioxins and tetrachlorodibenzofurans.

Table 3 illustrates typical levels of selected organic compounds observed in waste oils in the United States (U.S. EPA 1983).

TABLE 3
TYPICAL LEVELS OF SELECTED ORGANIC CONTAMINANTS OBSERVED IN WASTE OILS IN THE UNITED STATES

Contaminant	Concentration, mg/kg	
	Average	Range
Trichlorotrifluoroethanes	410	< 20 - 1900
1,1,1,-trichloroethane	700	< 20 - 14,800
Trichloroethylene	600	< 20 - 4900
Tetrachloroethylene	400	< 20 - 13,000
Toluene	3100	380 - 12,000
Phenol	25	< 5 - 70
2,4,6-trichlorophenol	< 5	< 5 - 10
N-nitrosodiphenylamine	< 5	< 5 - 10
Benz[a]anthracene	20	< 5 - 40
Benzo[a]pyrene	< 5	< 5 - 30
4,4',-DDE	< 5	< 5 - 10
PCB	< 5	< 0.1- 65

The most common analytical method currently used for the determination of these materials is gas chromatography. Appropriate sample cleanup, followed by a judicious choice of instrumental parameters such as column type, temperature profile, and carrier gas flow, will enable the analyst to accurately quantitate individual or total amounts of such chlorinated solvents as tetrachlorethylene ("perchlorethylene"), chlorobenzenes, etc.

However, the analysis of waste oils products for total PCB content appears to be considerably more complex problem.

Standard extraction and cleanup methodologies have been evaluated by OceanChem Laboratories and appear to yield consistently lower values for total PCB content, when compared to a modified cleanup using fuming sulphuric acid.

Table 4 lists values for total PCB levels in samples containing mixtures of petroleum hydrocarbons and commercial PCB mixtures.

TABLE 4
CONCENTRATIONS OF TOTAL PCB AND PCB CONTAMINATED PETROLEUM HYDROCARBONS AS DETERMINED BY STANDARD, AND MODIFIED ANALYTICAL METHODOLOGY

Sample	Total PCB Concentration mg/kg (ppm)	
	Standard Method	Modified Method
A	19	31
B	11	20
C	23	45
D	22	34
E	5	8
F	17	25
G	17	22
H	< 1	2
I	< 1	5
J	42	57
K	44	63

It should be noted that samples J and K are under the guideline limit of 50 mg/kg based on standard methodology, but over the limit on the modified analytical method.

As can be seen from the data, use of standard cleanup methodology on PCB contaminated hydrocarbon mixtures appears to yield consistently lower values for total PCB. Sample D and F above were initially submitted for analysis as pure transformer oils, and were analyzed using standard methodology. The results obtained were 35 and 24 mg/kg (ppm), respectively. These samples were subsequently inadvertently contaminated with diesel fuel, and yeilded the lower value as indicated in Table 2. Following discussion of the results with the client, the samples were re-analyzed using the modified cleanup protocol and yielded the original values, for total PCB content.

Waste oils may be blended with other petroleum hydrocarbons, prior to their use as a fuel source. Depending on the differences in the relative viscosities of the respective components the final blended material may not be homogenous. Due to the physical appearance of the majority of waste oil products, this inhomogeneity cannot be easily observed. This can have a significant impact in the regulatory perception of analytical data obtained on samples assumed to be duplicates, and analyzed as such by two different analytical facilities. The significant differences in the data obtained on such samples, assumed to be homogenous but in fact totally non-homogenous as a result of this attempted mixing, may be sufficient to cancel any legal position held by a regulatory agency.

Another source of observed inhomogeneity is the relatively high levels of suspended particulate often present in waste oils derived from used lubricating oils. Table 5 illustrates the change in PCB content of a surface sample of waste oil containing high levels of insoluble particulate. The sample was mechanically mixed prior to taking the initial sample. The sample was then allowed to stand undisburbed and subsequent samples were taken over a time span of 6 weeks.

TABLE 5
TEMPERAL CHANGES IN CONCENTRATIONS OF TOTAL PCB
IN AN UNDISTURBED WASTE OIL OR HIGH SOLIDS CONTENT

Sample Time Period	Total PCB Concentration mg/kg (ppm)
initial	605
+ 1 day	580
+ 7 days	425
+ 28 days	118
+ 42 days	102

As can be seen from the data, confirmatory analysis of a blended waste oil sample, assumed to be homogenous, may yield ambiguous results contradictory from a legalistic point of view.

The potential environmental implications of these observations are highly significant. Current fiscal restraints affecting many Provincial environmental regulatory agencies necessitate the maximization of financial resources. Lower unit analytical costs appear to aid in the achievement of this goal, however, these realistic budgetary considerations must be balanced by the increased costs that are necessitated by escalating demands for quality data which, at some future date will be required to withstand the scrutiny of the litigative procedures. Using the analysis of PCB residues in waste oil as an example, the added analytical costs resulting from increased labour, and material, and the more rigorous sample preparation, and cleanup required, could be perceived, in the case of a private contract laboratory, as an attempt to increase profits, or in the case of a government facility, as a justification for a larger infrastructure or operating budget. However, if we examine the American regulatory process as an example of the potential future direction in Canada, the need for an integrated approach to the management of materials such as waste oil is apparent. We must commit the resources and develop a long term management, strategy that will result in consistent inter-provincial regulations, realistically defined maximum allowable contaminant concentrations, and evaluation protocols that will withstand the test of intense litigation.

REFERENCES

Skinner, D.J. 1976. Prelminary Review of Used Lubricating Oils in Canada Environment Canada, Rept. EPS 3-WP-74-4.

U.S. DOE 1983. Report DOE/BC/10376-6.

THE NATIONAL INCINERATOR TESTING AND EVALUATION PROGRAM: AN ASSESSMENT OF PILOT SCALE EMISSION CONTROL

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SUMMARY

The National Incinerator Testing & Evaluation Program (NITEP), developed by Environment Canada, established as one of its objectives the assessment of air pollution control technologies suitable for the control of emissions from municipal energy-from-waste facilities. This assessment examined the removal of a wide range of organic and inorganic substances for a variety of operating conditions. The study utilized two lime based gas scrubbing devices developed by Flakt Canada, in combination with a fabric filter. The results demonstrate an ability to remove dioxins, furans, other organics, metals and acid gases to a very significant degree. Temperature was a most important parameter affecting removal efficiency of most pollutants examined.

Introduction

The literature has identified substantial variations in the quality of air emissions from municipal energy-from waste facilities. It is evident that modern well operated units tend to have lower emissions than older and less effectively operated facilities. Modern air emission control technologies play an important role in reducing emissions; however, there is very little data, particularly with respect to dioxins and other organic compounds, which quantify control capabilities.

Under the National Incinerator Testing & Evaluation Program (NITEP), Environment Canada, in co-operation with Flakt Canada Ltd., established an extensive test program to conclusively evaluate the capability of two control systems to remove particulate, acid gases, heavy metals, dioxins, furans and other organic compounds. In addition, the optimum operating conditions to minimize these contaminants were also of great interest.

In order to undertake this work, Flakt Canada Ltd. constructed a large scale pilot plant facility at the energy-from-waste plant owned by the Quebec Urban Community (CUQ) and operated by Montenay Inc. in Quebec City.

Incinerator Description

The CUQ incinerator is a mass burning design, developed in the early 1970's to burn as-received refuse in a water wall furnace. There are four incinerators, each rated at 227 tonnes per day with a common refuse storage

pit and stack. As illustrated in Figure 1, each incinerator consists of a vibrating feeder-hopper, feed chute, drying/burning/burn-out grates (Von-Roll design), refractory lined burning zone, water-walled, partially lined upper burning zone, a waste heat recovery boiler with superheater and economizer (Dominion Bridge), a two field electrostatic precipitator, an induced draft fan and a wet ash quench/removal system.

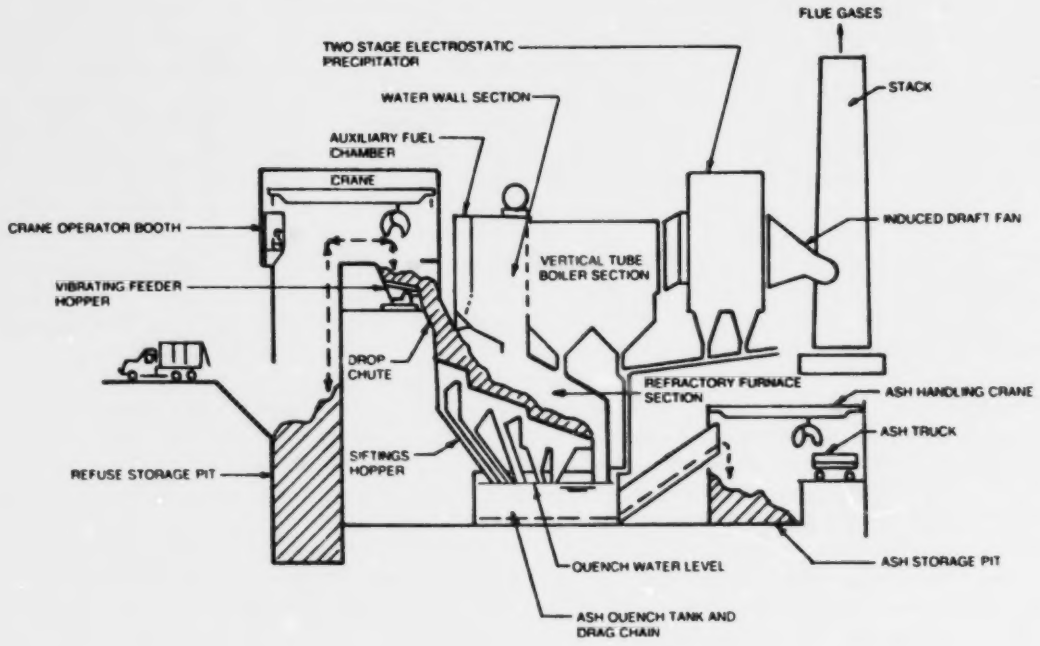


FIGURE 1
QUEBEC INCINERATOR
SCHEMATIC CROSS-SECTION

The incinerator receives municipal, commercial and suitable industrial solid waste. Each of the four units is capable of independent operation and is rated to produce 37,000 kg/hr of steam when burning 227 tonnes per day of refuse with a heating value of 13950 KJ/kg. All the steam generated is sold to Reed Paper Ltée at a guaranteed steady ($\pm$ 7%) flow and specified pressure range.

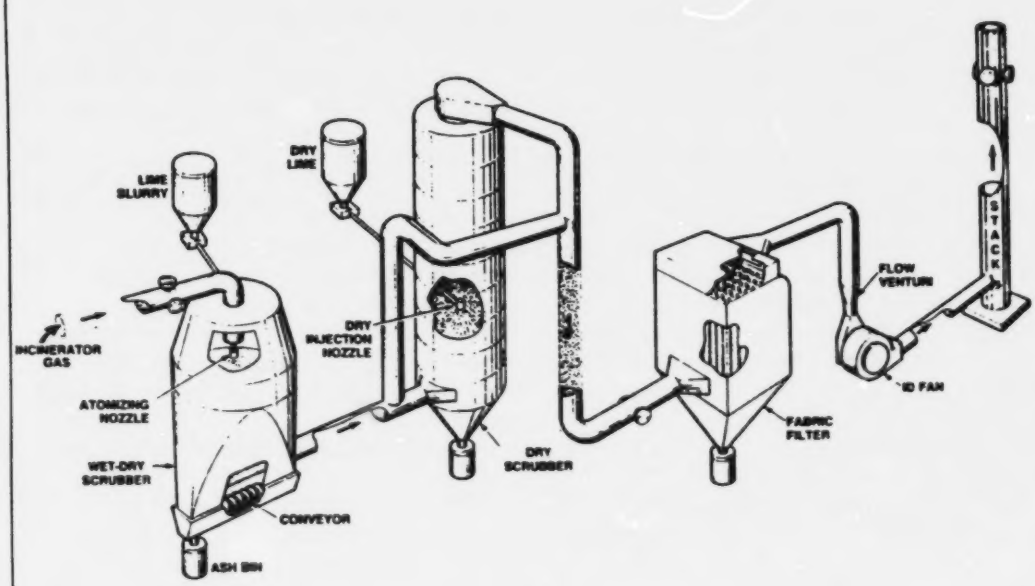
Pilot Plant Description

The principal components of the pilot plant, as shown in Figure 2, are as follows:

FIGURE 2

THE NATIONAL INCINERATOR TESTING AND EVALUATION PROGRAM (NITEP)

AIR POLLUTION CONTROL TECHNOLOGY



- a flue gas stream take-off duct (with 8 nozzles) from the electrostatic precipitator inlet of incinerator unit no. 3. The arrangement was employed to obtain a representative sample of flue gas to the pilot plant.
- a wet-dry scrubber - Flakt's DRYPAC design (also used as a gas cooler) with slurry spray nozzle and bottom screw conveyor.
- a dry scrubber - Flakt's DAS design, with a single dry lime injection nozzle and internal cyclone integral with the scrubber at the entrance.

- a pulse-jet fabric filter - Flatk's OPTIPULSE design, using high temperature Teflon bags as the filtering media with an air-to-cloth ratio of 4.4. Instrumentation included a pulse pressure controller, as well as duration and timer controls.

- an induced draft fan with flow venturi.

- a stack.

Ancillary equipment included by-pass ducts across the dry scrubber and fabric filter, removable ash hopper drums on each of the three vessels, flue gas duct isolating dampers, I.D. fan flow control damper, two lime slurry variable speed pumps with associated mix tanks, agitators, controls and a venturi/eductor dry lime feed system with variable control and lime silo. It must be noted that there are certain proprietary apsects to the design of the scrubbers and fabric filter, which would distinguish this equipment and its performance from similar equipment of other manufacturers.

The pilot plant was operated in one of two modes, as follows:

1) Dry System. The hot flue gas from the incinerator entered at about 255° to 270°C into the wet-dry scrubber (now in the role of a gas cooler) where it was cooled to the desired temperature with a water spray. It then entered the bottom of the dry scrubber tangentially into an internal cyclone. Dry hydrated lime was then air injected through a single nozzle countercurrent into the gas stream. The flue gas with entrained particulates and lime was then directed into the fabric filter dust collector.

2) Wet-Dry System. Hot flue gas from the incinerator entered the top of the wet-dry reactor at 255° to 270°C, where it was intimately mixed and cooled with a finely atomized lime slurry spray. The flue gas was then directed into the fabric filter dust collector.

For both systems, final removal of particulates, including lime, was accomplished with a fabric filter dust collector. Seventy-two bags arranged in 6 rows of 12 bags each were contained in a one compartment design. The bag material was Teflon with Gortex scrim, which is chemically inert to acid gases and has a maximum operating temperature of 250°C. The bags were supported on cylindrical wire cages with particulate collection occurring on the outside of the bag.

The pilot plant process control system was relatively uncomplicated. Temperature control was accomplished by either adjusting the rate of slurry into the wet-dry system or by water spray into the dry system. Flue gas flow was controlled by adjusting the damper at the inlet of the induced draft fan. To ensure constant flow was maintained during the tests, the pressure drop across a venturi upstream of the ID fan was continuously monitored.

Sampling Locations

Three sampling locations were selected to monitor the incinerator gases and to measure pollutants, in order to evaluate the performance of the two systems:

1. the inlet to the pilot plant to characterize the untreated raw gas from the incinerator

2. the mid-point prior to the fabric filter to characterize the scrubber performance

3. the outlet (i.e. stack) following the fabric filter to evaluate fabric filter performance and overall system performance.

In addition, all material settling out in the bottom hoppers of the scrubbers and the fabric filter were collected for analysis.

Quality Assurance / Quality Control

To ensure that the data was collected in a manner which would minimize any negative effects on data quality, an extensive third-party quality assurance/quality control program (QA/QC) was set up. This program component represented about 10% of the overall effort and was in addition to the internal QA/QC that is a routine part of all sampling programs.

Test Program Description

As in previous NITEP tests, the project was divided into two parts. The first was a characterization phase to familiarize project staff with the facility and to assess, using conventional parameters, the effect of the the various operating variables on system performance. Table I summarizes the characterization test conditions. The characterization phase test results identified that flue gas temperature and the ratio of lime to acid gas were the key parameters influencing removal efficiency of the pollutants measured.

Based on the first phase results, six performance test conditions were selected for a more detailed assessment of all parameters of interest (organics, metals, acid gases and conventional gas parameters). Table II summarizes these conditions with a rationale for selection. Each condition was tested twice to assess repeatability of results.

TABLE I SUMMARY OF CHARACTERIZATION TEST CONDITIONS

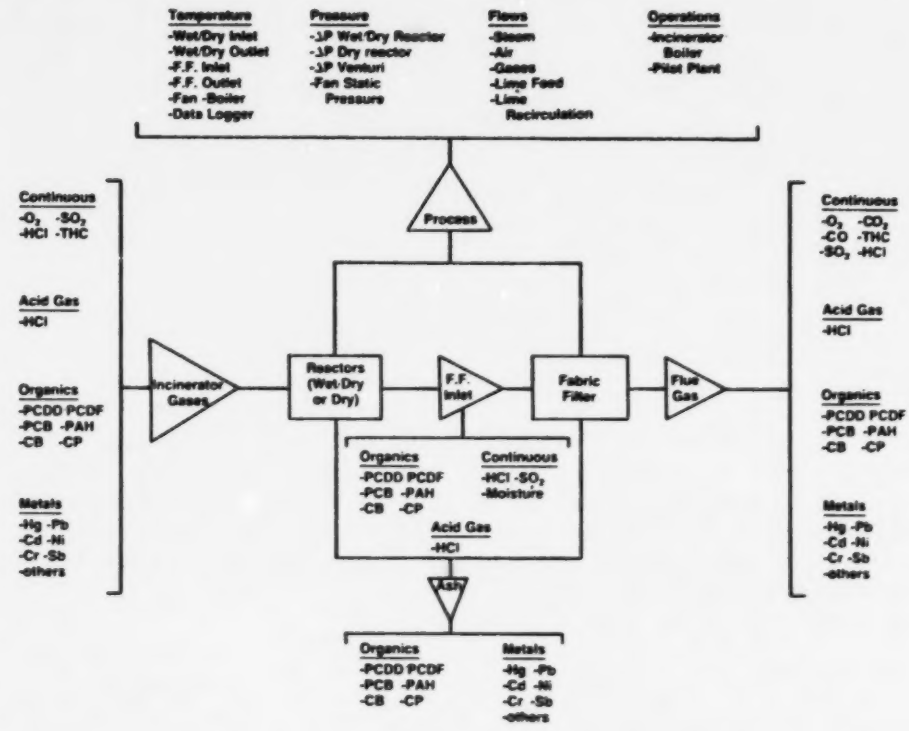
Operating Mode	Temperature After Cooling		Lime Feed Rate	Test No.
	Target °C	Actual °C		
Dry System				
Normal Temp. Operation	140	145	Normal	11
	140	151	High	4
	140	152	High (+ Recycle)	5
	140	151	Very high	3
High Temp. Operation	>200	222	Very high	2
Low Temp. Operation	125	133	Normal (+ Recycle)	12
Wet-Dry System				
Normal Temp. Operation	150	156	Normal	6, 10
	150	158	High	8
	150	158	High (+ Recycle)	9
	150	156	Very high	7
Low Temp. Operation	135	141	Normal	13
	135	144	Normal (+ Recycle)	14

TABLE II SELECTION OF PERFORMANCE TEST CONDITIONS

Operating Mode	Target Temp. Before Fabric Filter °C	Rationale
Dry System	> 200	To collect data with no gas cooling for contrast to the 3 other temperatures.
	140	Benchmark for comparison with other tests. Considered normal for full-scale.
	125	To observe potential improvements in organic removal at lower than normal temperatures.
	110	To push the limits of low temperature operation, particularly for impact on organics removal.
Wet-Dry System	140	Benchmark for comparison with other tests.
(+ Recycle)	140	To investigate whether lime recycle enhances the removal efficiency of organics and acid gases.

For each of the performance test conditions selected, sampling and data collection were conducted for the parameters shown in Figure 3. Ten manual sampling trains and 13 continuous gas monitors were operated simultaneously during these tests, requiring over 30 engineers and technicians.

FIGURE 3
PARAMETERS MEASURED DURING PERFORMANCE TESTS



Summary of Results

The most significant operating parameters measured during the performance tests are summarized in Table III.

TABLE III KEY OPERATING CONDITIONS

INCINERATOR	
STEAM	32,000 kg/hr
GAS AT BOILER OUTLET	280-300°C
GAS AT PILOT PLANT	250-270°C
PILOT PLANT	
LIME $Ca(OH)_2$	3.4-3.8 kg/hr
ΔP FABRIC FILTER	14-16 cm H_2O
OUTLET GAS FLOW	3,600 Nm^3/hr @ >200°C 4,100 4,300 Nm^3/hr (OTHER CONDITIONS)
CO	120-200 ppm (DRY)
OXYGEN	12-13% (DRY)
INLET PARTICULATE	6,000-8,000 mg/Nm^3 @ 8% O_2

The incinerator was operated as it normally operates at a steam production rate of 31,000 - 34,000 kg/hr. The average flow rate of the flue gas slip stream for the pilot plant was measured as 3,500 Nm^3/hr (dry). The key operating parameters for the pilot plant such as fabric filter pressure drop, lime flow rate, and flue gas temperature after cooling were carefully controlled at the selected conditions for each test.

Dioxin / Furan Results

For the parameter of greatest concern, dioxins, Table IV summarizes the inlet, mid-point and outlet concentrations and overall removal efficiencies. As is clearly evident, the greatest proportion of dioxin removal occurs across the fabric filter for both systems and under all temperature conditions tested.

Although the outlet concentration of dioxins was low for all operating conditions, there appeared to be some temperature effect at operating conditions below 140°C. Slightly higher removal efficiencies were observed at the lower temperatures.

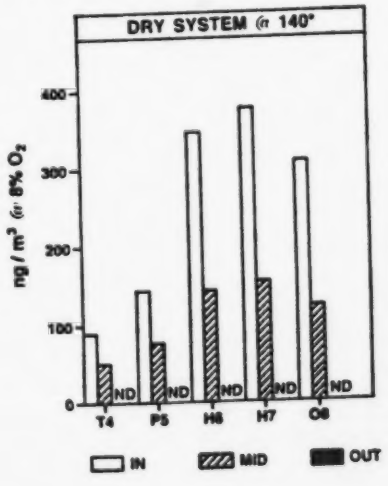
TABLE IV PCDD CONCENTRATION (ng/Nm^3 @ 8% O_2) IN FLUE GAS AND EFFICIENCY OF REMOVAL

Operating Condition	Dry System				Wet-Dry System	
	110°C	125°C	140°C	>200°C	140°C	140°C +Recycle
Inlet (ng/Nm^3)	580	1400	1300	1030	1100	1300
Mid Point (ng/Nm^3)	310	570	540	1140	840	1270
Outlet (ng/Nm^3)	0.2	ND	ND	6.1	ND	0.4
Efficiency (%)						
- Inlet/Midpoint	47	60	57	(11)	24	2
- Overall	> 99.9	> 99.9	> 99.9	99.4	> 99.9	>99.9

( ) denotes negatives.

The dioxin homologue distribution is similarly important and a typical example is shown in Figure 4 for the dry system operating at 140°C. The bell shape of the distribution curve is similar for all test conditions. The tetra's are the least prevalent with the 2, 3, 7, 8 isomer being generally less than 0.5% of the total dioxins.

FIGURE 4
TYPICAL PCDD HOMOLOGUE IN GAS

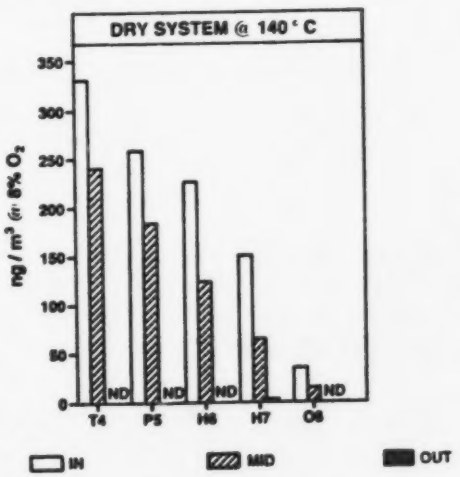


Furan removal efficiencies were similarly high (over 99.3%) as for dioxins. Table V provides the average data for each performance test condition. Figure 5 shows a typical furan homologue distribution. It is interesting to note that, in the furan homologue distribution, there is a greater prevalence of the tetra isomers.

TABLE V PCDF CONCENTRATIONS (ng/Nm^3 at 8% O_2) IN FLUE GAS AND EFFICIENCY OF REMOVAL

Operating Condition	Dry System				Wet-Dry System	
	110°C	125°C	140°C	>200°C	140°C	140°C +Recycle
Inlet (ng/Nm^3)	300	940	1000	560	660	860
Mid Point (ng/Nm^3)	270	440	630	490	690	1030
Outlet (ng/Nm^3)	2.3	ND	1.0	1.2	N.D	0.9
Efficiency (%)						
Inlet/Midpoint	11	54	37	13	-4	-21
Overall	99.3	> 99.9	99.9	99.8	> 99.9	99.9

FIGURE 5
TYPICAL PCDF HOMOLOGUE IN GAS



Tables VI and VII provide the concentrations of dioxin and furans in the hopper ashes collected from the three vessels. The concentrations are by far the greatest in the fabric filter ash. This was expected since the fabric filter had the greatest impact on dioxin and furan removal. It is significant to note that the fabric filter ash was much finer in appearance than the scrubbers ashes. The homologue distribution of dioxins and furans in the ash phase is essentiallly identical to that noted for the gas phase.

TABLE VI PCDD (ng/g) CONCENTRATION IN ASH

Operating Condition	Dry System				Wet-Dry System	
	110°C	125°C	140°C	>200°C	140°C	140°C +Recycle
Wet-Dry Scrubber Ash	13	14	6	6	6	12
Dry Scrubber Ash	160	64	85	31	N/A	N/A
Fabric Filter Ash	280	570	470	740	160	230

N/A = Not Applicable

TABLE VII PCDF (ng/g) CONCENTRATIONS IN ASH

Operating Condition	Dry Mode				Wet-Dry Mode	
	110°C	125°C	140°C	>200°C	140°C	140°C +Recycle
Wet-Dry Scrubber Ash	10	12	4	5	5	8
Dry Scrubber Ash	87	36	64	22	N/A	N/A
Fabric Filter Ash	160	320	400	320	130	170

N/A Not Applicable

Other Organics Results

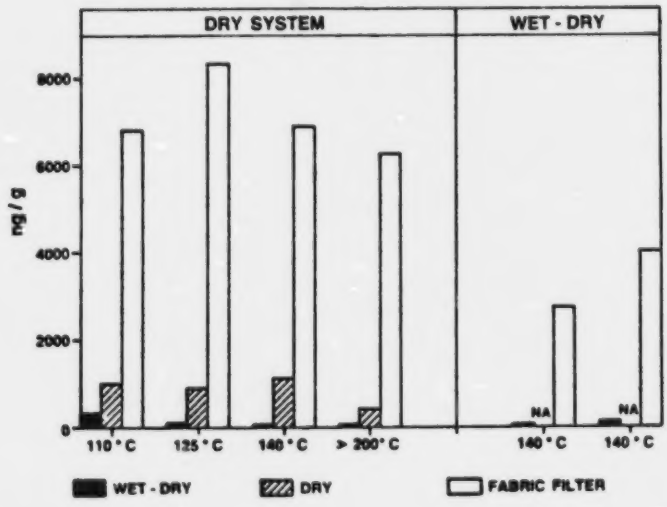
The removal effectiveness of other organics in the flue gas by the pilot plant is outlined in Table VIII. There are several significant differences between the removal effectiveness for chlorbenzenes (CB), chlorophenols (CP), polychlorinated biphenyls (PCB) and polycyclic aromatic hydrocarbons

(PAH). Essentially, the CB's, CP's and PCB's show a lower removal at higher temperatures, whereas the PAH's show the reverse relationship. At this point there is no firm rationale for this phenomena. As for dioxins and furans, the highest concentration for all the organic compounds occurs in the fabric filter ash. Figure 6 illustrates the concentrations of chlorobenzenes in the different ashes. For the other organic compounds, the distribution is similar, with highest concentrations occurring in the fabric filter ash.

TABLE VIII % REMOVAL OF OTHER ORGANICS

	Dry System				Wet-Dry System	
	110°C	125°C	140°C	200°C	140°C	140°C +Recycle
CB	95	98	98	62	>99	99
PCB	72	> 99	>99	54	>99	> 99
PAH	84	82	84	98	>99	79
CP	97	99	99	56	99	96

FIGURE 6
CP CONCENTRATION IN ASHES



Metals Results

Metal emissions are presented in Table IX indicating the overall removal effectiveness of the control system for eight of the 27 metals tested. As shown in more detail in Table X, the only notable exception occurs with

mercury at the higher (> 200°C) temperature tested, at which there is no removal of mercury. Mercury removal is significantly enhanced by operating the system at a flue gas temperature below 140°C.

TABLE IX

INLET/OUTLET METAL CONCENTRATIONS ($\mu g/Nm^3$ @ 8% O_2)

METAL	INLET	OUTLET
ZINC	80,000 - 110,000	2 - 7
CADMIUM	1,000 - 1,500	ND - 0.4
LEAD	30,000 - 45.000	ND - 5
CHROMIUM	1,400 - 3,000	ND - 1
NICKEL	700 - 2,500	0.4 - 1.3
ARSENIC	80 - 150	0.02 - 0.04
ANTIMONY	800 - 2,200	0.2 - 0.6
MERCURY	200 - 500	10 - 600

TABLE X

INLET/OUTLET MERCURY CONCENTRATIONS ($\mu g/Nm^3$ @ 8% O_2)

OPERATION DRY SYSTEM	INLET	OUTLET
110°C	440	40
125°C	480	13
140°C	320	20
>200°C	450	610
WET-DRY SYSTEM		
140°C	190	10
140°C + RECYCLE	360	19

In order to ensure that trace quantities of metals and organics in the lime did not contribute significantly to the observed levels in the ashes, an analysis was carried out and is reported in Table XI. In general, it may be concluded that metals present in the lime did not contribute significantly to the metal concentration in the ash. Organic analysis showed the lime to be a non-contributor to the presence of organic substances in the ash.

TABLE XI METAL CONCENTRATIONS IN LIME VERSUS METALS IN HOPPER ASH (ug/g)

Metal	Lime	Dry System	Wet-Dry System	
		Fabric Filter	Wet-Dry Scrubber	Fabric Filter
Zinc	40	18 000	4 000	13 000
Cadmium	10	320	35	180
Lead	250	7 800	1 500	6 000
Chromium	40	170	190	200
Nickel	30	47	100	95
Antimony	ND	280	40	200
Arsenic	4	42	5	20
Mercury	ND	220	4	90

Acid Gas Results

The ability of the two systems to reduce the emission of acid gases was evaluated for several different operating modes. Tables XII demonstrates the impact of operating conditions on acid gas removal. It is clearly evident that temperature is a major factor for acid gas removal, which is consistent with observations for organics and metals. At the lower operating temperatures, the removal efficiencies are significantly higher than at the higher temperatures. There appears to be no significant difference between the dry and wet-dry systems for acid gases removal; however, the recycle condition (wet-dry mode) did show that less lime was required to achieve the same removal efficiency as without recycle. This is a significant finding as it has the potential to reduce operating costs by reducing lime consumption.

TABLE XII HCl & SO_2 CONCENTRATIONS (@ 8% O_2) & COLLECTION EFFICIENCY

Operating Condition	Dry System				Wet-Dry System	
Flue Gas Temp. at F.F. Inlet	110°C	125°C	140°C	>200°C	140°C	140°C +Recycle
Stoichiometric Ratio	1.21	1.10	1.10	1.60	1.36	1.16
Hydrogen Chloride						
Inlet (ppm)	410	430	450	360	360	450
Midpoint (ppm)	15	66	120	190	140	140
Outlet (ppm)	7	9	28	84	28	40
Eff to Midpoint (%)	96	85	73	47	56	68
Eff Overall (%)	98	98	94	77	91	91
Sulphur Dioxide						
Inlet (ppm)	110	110	80	110	100	100
Midpoint (ppm)	23	63	61	99	63	66
Outlet (ppm)	4	10	39	79	33	40
Eff to Midpoint (%)	80	45	35	11	36	35
Eff Overall (%)	96	92	58	30	66	61

Conclusions

The following key conclusions have been drawn from the extensive test data on the Flakt pilot plant system:

1. Both the wet-dry system using lime slurry and the dry system using powdered lime, followed by a fabric filter, are capable of high removal efficiency for all pollutants of concern, with no significant difference in removal efficiency by either system.

2. Cooling of the flue gas temperature was a key operating parameter for effective removal of HCl, SO_2 and mercury for both systems.

3. The removal efficiencies for dioxins and furans were very high, exceeding 99%. For most test runs, the concentrations of dioxins and furans after the control system approached the detection limits of the sampling and analytical methods employed.

4. The highest dioxin and furan concentrations in the ashes occurred in the fabric filter ash and the lowest concentrations were found in the scrubber ashes. These results were anticipated based on the high removal efficiency of dioxins and furans across the fabric filter collector.

5. Other trace organics, such as chlorobenzenes (CB), polychlorinated biphenyls (PCB), chlorophenols (CP) and polycyclic aromatic hydrocarbons (PAH) were also efficiently removed (80 - 99%) by both systems when operated under cooled flue gas conditions.

6. Concentrations of trace organics in the various hopper ashes followed a simlar pattern as for dioxins and furans, whereby the highest concentrations occurred in the fabric filter ash.

7. Metal collection efficiencies generally exceeded 99.9% with both systems except for mercury, for which flue gas cooling was essential to maintain a high removal efficiency.

8. Low emissions of acid gas can be accomplished by either increasing the ratio of lime to acid gas or by cooling the flue gases. However, flue gas cooling is a more economical approach since increasing lime utilization is more costly.

9. Ash recycle (i.e. fabric filter ash containing some residual unreacted lime) added to the fresh make-up lime was beneficial in providing the same SO_2 removal efficiency as the no-recycle condition. By recycling ash, less fresh lime was used, which reduces operating cost.

10. Two key independent variables tested were flue gas temperature control and the ratio of lime to acid gas concentration. Temperature was found to be the most significant variable in affecting removal efficiency.

GENERATION OF ELECTRICITY FROM LANDFILL GAS AT OMEGA HILLS AND METRO LANDFILLS MILWAUKEE, WISCONSIN

KEVIN P. O'TOOLE*

(ABSTRACT)

At two major landfills, located several miles from downtown Milwaukee, Wisconsin, solving the need for landfill gas control has created a unique opportunity. Completed in December, 1985, gas recovery systems are generating electricity which was being sold to the local electric utility. The fast-track project required only four months from start of design to full operation.

Owned by Waste Management of Wisconsin, Inc., the systems cost approximately $8,500,000. The Omega Hills facility is believed to be the world's largest to produce electricity from landfill gas. The combined generating capacity is 9.9 megawatts.

The Omega Hills site is approximately 83 acres and the Metro site is 60 acres. The collection systems are designed to handle over 9.5 million cubic feet of gas daily. Three 3.3 megawatt gas fired turbine generator systems are fed by three 3-stage piston compressors. Raw landfill gas is compressed 175 psi with scrubbing for particulate removal. The 175 psi superheated gas is transported underground from the compressor building to the turbine building. Here the gas fuels turbines which each produce the equivalent of 4,500 HP. Electricity generated at 4,160 volts is stepped up to 26,400 volts and sold to Wisconsin Electric Power Company. Each turbine generator system is providing the energy equivalent to satisfy the needs of 5,000 homes, for a total of 15,000.

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Introduction

In late July 1985, Waste Management of Wisconsin, Inc. (WMWI) authorized the development of two facilities to recover landfill gas and convert it to electrical energy. The design and construction of these facilities, located near metropolitan Milwaukee, Wisconsin, were unique and challenging because few similar facilities exist. Even more challenging, however, was WMWI's goal: full-scale operation of the facilities no later than December 31, 1986.

This paper describes WMWI's gas collection and electrical generation facilities and summarizes several key design criteria and procurement methods which made these projects a success.

Background

WMWI selected two landfills to receive these facilities - the Omega Hills Landfill located in Germantown, Wisconsin, and the Metro Landfill located in Franklin, Wisconsin.

The 83-acre Omega Hills Landfill is located 15 miles from downtown Milwaukee. Serving the Milwaukee metropolitan area (population 1.2 million according to 1980 census figures), it is Wisconsin's largest landfill. Since commencing operation is 1972, approximately 12 million cubic yards of municipal, industrial, and commercial wastes have been deposited. Non-hazardous liquid waste and sludges containing free liquids were accepted until early 1985 for co-disposal, using the absorptive capacity of the solid waste. Average refuse depth is 120 feet with a maximum depth of 210 feet.

Landfill Gas Collection Systems

In 1982, WMWI conducted pump testing at the Omega Hills Landfill to assist in the determination of gas generation rates. After compiling the data, it was apparent that gas management would be necessary. A 1984 monitoring program at Omega Hills documented landfill gas migration and vegetative stress in the final clay cover. In addition, odor from escaping gas was an aesthetic concern. In response to these site conditions, a gas extraction system was designed in late 1984 and construction began in the spring of 1985.

The gas extraction system was designed to provide a zero pressure envelope throughout most of the landfill by withdrawing gas at a rate equal to its production. Sixty-five gas extraction points are located throughout the Omega Hills Landfill, consisting of 45 wells, 11 trenches, and 9 leachate collection system connections. An average well spacing of 300 feet was used to provide zone of influence overlap.

A 19,000 foot long gas collection header system was designed to handle up to 7 million cubic feet of gas per day. The header system consists of high density polyethylene pipe (HDPE) ranging from 4 inches to 24 inches in diameter. A flexible coupling connects the well assembly to the header and allows for differential settlement between the two components.

The header system is unique in comparison to sewer or gas lines, in that it is designed to handle both gas and liquid flow. Minimum slopes are maintained on the header to facilitate drainage of condensate to six low points. Barometric drip legs at the low points allow gravity drainage of condensate from the header without air intrusion. Condensate is discharged into the existing leachate control piping system which flows to the on-site wastewater pretreatment facility.

At some locations in the header, counter-current flow occurs where gas flow is in the opposite direction of condensate flow. To successfully handle counter-current flow, a minimum pipe slope was maintained. To minimize head loss, the header lines generally were sized for maximum gas velocities of 30 to 35 feet per second.

During design, it was necessary to take construction costs into consideration as well as system performance. Construction in a landfill, particularly within refuse, is costly. Therefore the header pipe was designed to be installed as close to the surface as possible following the surface contours of the landfill.

Wells and header system construction began in Spring 1985 and was approximately 50 percent complete when WMWI decided to implement electrical generation. At the Metro Landfill, however, only preliminary pump testing had been completed prior to the go-ahead decision.

At Metro, the gas collection system was an early design consideration. Approximately one week after the authorization to proceed, gas extraction point locations were designed and staked in the field. A design report was prepared and forwarded to the Wisconsin Department of Natural Resources (DNR). The DNR promptly reviewed and approved the gas well locations and design. Approximately one week later, a contractor began installation of the gas wells at the Metro Landfill. The Metro collection system consists of 22 wells with an additional 12 wells planned. More than a mile of HDPE header pipe connects the wells to the electrical generation facilities.

During gas well installation, design continued on the header system. The design parameters at the Metro System were virtually identical to those for Omega Hills. The primary difference between the two systems is in condensate handling. At Omega, the condensate is discharged to an on-site treatment facility. At Metro, the condensate is handled separately from other on-site leachate collection. Condensate is removed from the header system through barometric drip legs located at three header low points, and is collected in tanks. The main condensate tank is a 10,000-gallon, double-walled, coated tank. The condensate is periodically removed from the tanks for off-site treatment.

The design of the header system for Metro was completed within one month and submitted to the DNR for review and approval. The DNR responded by reviewing and issuing approval in one week. Construction on the header system began in mid-September 1985.

Electrical Generation Facilities

The remainder of this paper addresses the design and construction of the electrical generation facilities at each site. Early in the project, a decision was made to make the two facilities as similar as possible to save money and time during design and construction. The buildings at both facilities are virtually identical, and design and construction proceeded on an identical time line. Therefore, except for the few major differences, this paper does not differentiate between the Omega Hills and Metro facilities.

Overall Layout

The electrical generation facilities consist of three major components: a 1,600 square foot compressor building, a 3,100 square foot gas turbine building, and a gas flaring station. The gas flaring station will be used only as a backup should the electrical generation facilities be down for any length of time. The general process flow follows (See Figure 1):

> Landfill gas is withdrawn from the wells and is transported through the header to the gas compressor building. In the compressor building, the gas first flows through a water wash scrubber for particulate removal and is compressed to 190 psig. From the compressor building it is transported through underground piping to the turbine building where it fuels the gas fired turbine engines which drive the electrical generated at 4,160 volts is stepped up in the control/transformer room to 26.4 kilovolts, and enters the Wisconsin Electric Power Company utility grid just outside the control room.

Major Equipment

The turbine generator sets and the compressors were being evaluated by the energy recovery staff of Waste Management, Inc., in Oakbrook, Illinois prior to the August 1985 authorization to proceed. Waste Management's Oak Brook staff has experience with the compressors at a gas recovery facility in Pompano Beach, Florida, and had nearly completed an evaluation of both turbine and reciprocal engine electrical generation sets when the Omega Hills/Metro project began. In the project's early states, WMI Oak Brook selected Solar Turbine, Inc., Centaur gas turbine generator sets because of the large scale needed, the availability of turbines for almost immediate delivery to the sites, and the suitability of the equipment for landfill gas application.

The turbine generator set is skid mounted and weighs approximately 20 tons. Each turbine generator set can produce approximately 3.3 megawatts of electricity. At this loading, the turbine requires approximately 1,600 standard cubic feet per minute of landfill gas at 500 BTU's per cubic foot of 2.3 million cubic feet of gas each day.

The compressors are manufactured by Hall Systems, Inc., Tulsa, Oklahoma. The first stage of the compressor consists of a centrifugal blower capable of producing up to a 60-inch water column head. The centrifugal blower provides the head and flow rates required to withdraw the landfill gas from the collection system. The gas then enters two additional stages of compression with each stage followed by cooling of the gas. After compression, gas at a delivery pressure of 190 psig is fed to underground piping and transported to the turbine generator sets. To prevent liquid condensation between the compressors and the turbine, a portion of the gas bypasses the final cooling stage and superheats the rest of the gas. The compressor is driven by a 600-horsepower electric motor. The 23-ton compressor package--which includes the centrifugal blower, a piston type, two-stage compressor, motor, gas scrubbers, and gas chiller unit--is skid mounted.

Structures

The compressor and turbine building structures consist of decorative masonry wall and a cast-in-place concrete roof. Masonry was selected over other building types for several reasons:

- Masonry materials were more readily available and construction could begin almost immediately.
- The masonry buildings are more adaptable should major changes occur during construction. This was a possibility since equipment shop drawings were not available, and design of other major systems (HVAC, plumbing, electrical) was only 10 percent complete when building construction began.
- The masonry building was more adaptable to the necessary soundproofing treatment.

Special attention was paid to the acoustical treatment of the facilities because much of the equipment produced significant noise levels which could not be permitted to adversely impact adjacent communities. An acoustical evaluation was prepared for all equipment ranging from the gas turbine exhaust (which is acknowledged to be the loudest noise source), HVAC equipment motors, and turbine oil cooler motors. The study concluded that certain design and construction techniques be used, including:

- Insulated HVAC ductwork inside the building and providing bends in the ductwork to prevent sound from exiting directly.
- Acoustical baffles inside critical portion of the HVAC ductwork.
- Acoustical concrete block as a part of the exterior wall system of the building.
- Vertical acoustical baffles between the precast joints of the roof structure to absorb sound.
- Silencers on the turbine generator exhaust system.

Use of these design and construction techniques has resulted in a very low exterior noise level. Although noise levels within the buildings require the use of ear protection, sound levels outside the buildings are very low and within acceptable limits.

The HVAC system for each building was designed to provide sufficient air flow to keep each piece of equipment within acceptable operating temperature ranges. The equipment generates sufficient heat to maintain above-freezing temperatures in the buildings in winter without a supplemental heat source. In summer, the compressor building air is exchanged 1.7 times per minute to maintain proper operating temperatures. Under colder outside temperatures, air is recycled to maintain at least 60 degrees interior temperatures

The floor and site plans for each facility were developed within 10 days of project initiation. Soils exploration for foundation design followed immediately. During the first two weeks of the project, a contractor was selected and construction of the buildings began approximately 15 days into the project.

The approach was basically design/build. Construction in many areas followed design by only a few days and sometimes only hours. Throughout the project, careful attention was paid to the necessary permits ranging from State Department of Industry, Labor, Health and Human Relations building approvals to local planning permits. Only through the cooperation and dedication of all parties were all permit requirements met.

Construction proceeded seven days per week, and averaged 12 hours per day. Bay late November 1985, the compressor and turbine buildings were ready for installation of the major equipment. As mentioned previously, the turbine generator set and compressors are skid mounted and were delivered to the site by truck. The first piece of equipment--a compressor, arrived at Omega Hills on December 1, and the last piece of equipment, a turbine, was installed at Metro on December 5, 1985. Final installation of plumbing, gas lines, electrical systems, lighting, HVAC, and painting was completed within the next two weeks. The system went on-line on December 15, 1985 at Metro and December 17, 1985, at Omega Hills.

System Economics

Project costs, including equipment, totaled approximately $8.5 million, and payback is expected within 7-8 years. WMWI estimates that as much as $60 million in revenues over the next 15 years can be generated at both sites.

System Startup

In general, the system startup consisted on the following steps:

1. All gas collection pipes pressure tested.
2. Based on anticipated extraction rates and flows, the valves at each well head assembly were preset.
3. The blower, which is part of the gas flare station, was started and gas was drawn from the header system for a period of time to purge the system and obtain relatively steady-state flow in terms of methane concentration.
4. Preliminary balancing of the wells was completed using portable methane and oxygen meters to maximize methane concentration and minimize oxygen intrusion.
5. The gas flare blower was shut down and the compressor energized. Gas was allowed to vent for a period of time until the compressor operation and gas flow had stabilized.
6. Gas turbines were started, and slowly the electrical generation load was increased.

The entire startup operation occurred over several weeks, with balancing of the wells occurring throughout that same time period.

Summary

WMWI's goal of placing the facilities on-line no later than December 31, 1985, was met. Both facilities have been operating continuously since that time and have exceeded the estimated on-line time. The significance of this project is evident.

1. A previously wasted resource is now being used efficiently and cost-effectively.
2. The project has demonstrated the ability of business, industry, and government to work together to solve a shared problem.
3. The technology developed at these two facilities is transferable, and in fact, Waste Management, Inc., has plans underway for several more facilities across the country.

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NATIONAL SOLID WASTE MANAGEMENT ASSOCIATION

ANNUAL MEETING

HALIFAX, NOVA SCOTIA

PROVINCIAL INITIATIVES IN THE INDUSTRIAL FOUR Rs IN ONTARIO

INTRODUCTION

For the past four years, the Ontario Ministry of the Environment, through its Waste Management Branch, has developed and implemented a major program for the recycling of municipal solid wastes, through municipalities for both "for-profit" and "not-for-profit" organizations in various communities. This program has had notable success. With increased funding and the participation of industry, municipal recycling is poised for a great deal of success in the future.

The reduction of industrial wastes through re-use, reduction, recycling or recovery was not a specified program of the Ministry of the Environment until June of 1986. Although specific data is hard to come by, it is estimated that approximately 50% of the solid waste entering Ontario's landfill sites is of industrial origin. For this reason alone, it is imperative that the Ontario government undertake a concerted effort to reduce the amount of industrial waste being placed in Ontario's landfill sites.

ONTARIO MINISTRY OF THE ENVIRONMENT 4R PROGRAM

The slide outlines the organization of a new section within the Waste Management Branch of the Ministry of the Environment. There are three units within this section: the first, dealing with municipal waste reduction programs, the second, dealing with industrial waste reduction programs and the third, dealing with market development and promotional activities.

I have already mentioned briefly the municipal recycling program which is presently under way. I will not dwell on it, but I do want to outline it to give some perspective. The branch has a two million dollar budget at present for assistance to municipalities to undertake primarily curbside recycling programs. This money is matched by certain industries which are involved in the production, distribution or retailing of carbonated soft drink beverages in the province. A new provincial regulation requires that non-refillable soft drink containers be recycled to a level of 50% of their production units by 1988. In order to achieve this goal, the regulation stipulates that industry support multi-material recycling as well as their own containers. The industries have agreed to match the provincial budget for recycling. The current estimates of both the Ministry and the industry associations are that the two programs will result in the recycling of approximately 500,000 tons of newsprint, beverage containers and related products within five years.

In addition, the Ministry has initiated a household hazardous waste collection program, which provides technical and financial assistance to municipalities for running these projects. As well as providing for a more superior method of handling and disposal of these wastes and providing a needed service for residents, it is hoped the program will also raise the awareness of the public to its role and responsibilities in waste management issues.

The market development and promotion unit, is provided to assist both the municipal and the industrial reduction units by developing educational and promotionol materials and by assisting in the development of markets for recycled products.

The new industrial program unit, which has just recently been staffed, has the mandate of developing a provincial 4R's program for industrial wastes. While the program is not fully defined at this time, I can speak at least in a general way of the initiatives, which we hope that we can pursue in the near future.

INFORMATION

On the so called soft side of the effort, we intend to develop, in co-operation with the Ontario Waste Management Corporation (a crown corporation set-up for the purpose of constructing and operating hazardous or special waste treatment and disposal facilities and for the reduction of the amounts of those wastes produced by Ontario's industry), a library of information which will be available to interested industries. The information which we have begun to accumulate, will be in the form of technologies which have been developed and successfully used in Ontario and other jurisdictions; so-called success stories and any other related information and statistics which are felt to be important in this area. The library may be in-house, or operated by an outside agency.

At the same time, the branch will be developing guidelines and procedures to form a basic tool kit for use by field staff of the Ministry. There are approximately 30,000 industries in Ontario and it is readily apparent that no head office group can hope to have direct contact with any but a small minority of that large number. However, the Ministry has 27 field offices and a fairly large number of staff who deal with industry on a regular basis. These dealings are of necessity primarily of a regulatory nature. However, it is the intention of the branch to equip field staff with sufficient knowledge and information that, in the course of their regulatory work, they can also speak to appropriate industrial staff on the economic and process benefits of investigating the potential for waste reduction within their particular plant.

ONTARIO WASTE MANAGEMENT CORPORATION

The Ministry of the Environment and the Ontario Waste Management Corporation are working in close liaison to effect the 4R goals of both agencies with Ontario's industry. As I mentioned, the Corporation's mandate is targeted at special wastes. It is the intention of both agencies that they are knowledgeable of each others activities, so that whichever is talking to an industry at a particular time will be able to advise on the programs of the other agency, if they are applicable in a particular circumstance.

The Corporation has specific program initiatives under way or in development and I will address them briefly.

1. **Technical Library** Again as I mentioned, the Corporation and the Ministry will be working together to develop a technical library which will include basic support technical literature; computerized data bases of relevant waste reduction information and a compilation of successful 4R case histories.

2. **Waste Exchanges** Both agencies strongly support the concept of waste material exchanges. The Ministry of the Environment currently financially assists the Canadian Waste Materials Exchange and the Ontario Waste Management Corporation currently financially assists the Ontario Waste Management Exchange. It is anticipated that MOE will also support the Ontario exchange in order that a full-time person can be made available to review contacts made through the Canadian Exchange that have not resulted in actual contracts being struck. The purpose is to determine the reasons for the lack of a contract and to determine whether initiatives can be taken to enable a successful contract.

WASTE CHARACTERIZATION

The OWMC can provide minor treatability or waste characterization services in support of 4R's efforts.

GENERAL LIAISON WITH INDIVIDUALS, CORPORATIONS, ASSOCIATIONS, ETC.

The OWMC and indeed the MOE will both put a lot of effort into education through direct contact with industrial associations, individual firms, research institutes and other governmental agencies.

I will now return to some other initiatives being considered by MOE.

TECHNOLOGY DEMONSTRATION

The Ministry hopes to have in place in the near future, a program which will enable financial assistance to be provided to firms for the development of technology demonstrations with a direct application to the reduction of industrial waste going to landfill. This program is not well defined at this stage; however, it is likely to be in the form of seed money or grants for feasibility studies. The budget expectations in this area are not known at this time and that will be a great determinant of the extent of such programs.

WASTE EXCHANGES

As mentioned under the comments with respect to the Ontario Waste Management Corporation, the branch, in co- operation with the Ontario Research Foundation, hopes to develop a much more pro-active role for both the Canadian and the Ontario Waste Exchanges. This is seen to be an area of great opportunity which has not really fulfilled its potential. As mentioned, the intention is to cofund with OWMC the employment of a full-time person to work with the Canadian Waste Exchange lists to attempt to determine why contacts do not result in the actual completion of a deal. It is hoped that this will generate leads as to required studies, research, demonstration projects and the like, to try to overcome whatever barriers seem to be precluding the consummation of a deal.

WASTE AUDITS

The Ministry and the Corporation both feel that the use of waste audits is a very promising vehicle by which the 4Rs can be achieved in a particular industry. Neither agency will have sufficient staff to carry out a waste audit; however, it is hoped that procedural manuals and other information can be made available to industry to carry out their own. In addition, the Ministry is presently discussing with the "On-site" program, operated by energy Pathways, ways to assist in the funding of this program. The On-Site program in Ontario has achieved considerable success in placing unemployed engineers in companies for up to six months to work on pollution control and waste reduction initiatives. The intent of the program, of course, is to see these people become permanently employed. The Ministry sees this program as being directly related to its mandate and is probably prepared to financially assist the further development of this program.

Several industrial associations have indicated that theyh have access to individuals who have been employed in industry and who have taken early retirement for a number of reasons and who would be available to carry out such audits. We intend to pursue the use of these persons to again further asist us in the implementation of our programs.

REGULATORY

An important initiative which was started by the Ministry with the passage of Regulation 309 is the definition of waste derived fuel. The reduction unit intends to review the success of this definition in providing an easier regulatory approval process for the use of waste as fuel.

DATA BASE

With the registration of all waste streams in the province as required by regulation 309 and the on going manifest of deliveries of wastes from the generator through the carrier to ultimate treatment or disposal, the branch now has a wealth of information on industrial waste production in the province. It is intended to take advantage of this information and to look for opportunities for waste reduction and to follow these up wherever possible.

In conclusion, it is, I'm sure, obvious to you that this is a very new initiative by the province; the program is clearly not fully developed at this time; however, we hope that you agree that this is a very necessary undertaking and that we are on the right track. We most certainly welcome any suggestions for ways of achieving impact on the amount of industrial waste going to Ontario's landfill sites. It is unlikely that very large amounts of money will be available for this undertaking but it is hoped that through our initiatives we can certainly raise the level of consciousness of industry of the benefits to the 4Rs for both the province as a whole and, of course, for individual companies which presently pay very large sums of money for the disposal of their wastes. We are and will be working very closely with the Ontario Waste Management Corporation and together we expect to achieve important reductions. Together with the on going municipal recycling programs, we are prepared to meet head-on the challenge of reducing Ontario's dependence on landfill sites for the disposal or as we often refer to it, the storage of wastes in this province. Thank you very much.

3M'S POLLUTION PREVENTION PAYS PROGRAM

3M Canada Corporation

Allan Mills

Paper unavailable at time of printing

ANOTHER LOOK AT HOW RE-CYCLED CULLET AFFECTS GLASS CONTAINER MANUFACTURE.

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ABSTRACT:

Preservation of natural resources, reductions in litter, energy conservation, reduced waste disposal costs and reduced raw material costs are the potential fruits of an effective container glass cullet re-cycling program. The pitfalls include: inefficient collection mechanisms, costly sorting processes, chronic manufacturing defects and structural failure of the glass furnace bottom.

The risk/reward ratio is now in favour of the large scale re-cycling of quality post-consumer glass container cullet. The sources, beneficiation, handling and batching techniques are reviewed with reference to the literature and practical experience. Procedures for quantifying and specifying post-consumer cullet quality are reviewed. The operation of a re-cycled cullet beneficiation facility is detailed; and the impact of its output on container glass quality is discussed.

The observed impacts of re-cycled cullet chemical variations is compared with those reported in the literature. This is then used to define practical selection, handling and usage levels for the post-consumer cullet currently available for use. The melt energy savings resulting from a range of cullet ratios is defined. The demand for post-consumer cullet is estimated based upon practical usage limitations; and this is compared with anticipated supply. The necessary improvements in re-cycling technology to permit larger usage rates are reviewed.

INTRODUCTION:

For the purpose of this discussion, the term 'post-consumer' cullet will include all glass sources suitable for glass container manufacture and returned from locations outside the glass plant boundaries. Other expressions which have the same meaning are 'foreign', 're-cycled' and 'purchased' cullet.

North American society is slowly becoming aware of what other societies have known for decades; a motivated and conscientious consumer can, through appropriate source separation of re-cyclable materials, return a potentially valuable feedstock to the manufacturer and divert solid waste from landfill.

Successful mass re-cycling (1), as practiced in several European countries, requires an aware and conscientious public. It also requires an industrial infrastructure capable of accommodating this sort of raw material. Both have taken time to evolve.

North American policy makers will thus need to learn patience and concentrate on educating the next generation of consumers. It is the responsibility of the private sector to confirm the technical appropriateness of re-cycling programs. Commercial appropriateness can only be assessed in full knowledge of

the technical implications of each re-cycling sub-system.

Analyses of this type are now underway in Canada, leading to many claims under the umbrella of re-cycling (1, 2, 3). These include: energy savings, resource conservation and reductions in pollution, litter and solid waste land-fill requirements. In addition, operating and capital cost savings in manufacturing are forecast, leading to reduction in the ultimate cost of products to consumers.

This enthusiasm needs to be balanced with the inevitable reality of present social and technical constraints. Consumers tend to be negligent in separating re-cyclable materials (4). Cross-contamination is common. Industry is geared to the automated receipt, storage and processing of virgin raw materials. The costs of modifying these systems are substantial.

In spite of this, the glass container industry has seen an opportunity in re-cycling. As stated by Owens-Illinois, Inc. (6):

"Primarily re-cycling (of glass) is done for three reasons:

As an alternative to restrictable packaging legislation.

Because cullet has value.

To maintain market position."

With these or, at least, similar views, Consumers Glass has undertaken a review of the short and long term impacts of foreign cullet re-cycling on its operation. Several aspects of this analysis are presented in this paper and they include:

Current and projected sources of re-cyclable cullet.

The 'state of the art' in cullet beneficiation.

The effect of re-cycled cullet on glass quality, melt energy consumption and furnace operating parameters.

Recommendations for optimizing operations at high re-cycled cullet usage levels.

SOURCE AND DEMAND FOR POST-CONSUMERS CULLET:

In 1982, Consumers Glass used slightly in excess of 35,000 tonnes of re-cycled cullet. In 1985, purchases of available, usable re-cycled cullet were in excess of 100,000 tonnes. An up-dated objective of 115,000 tonnes in 1987 is realizeable. This cullet is primarily Emerald green, amber and color mixed container glass, sheet and plate glass. However, small but increasing amounts of color sorted flint (clear) container glass are anticipated. This suggests that, on the average, available foreign cullet will constitute 20 to 30% of the total glass production over the next five years.

A similar analysis indicates an additional 100,000 tonnes per year of post-consumer cullet might be accommodated in flint glass production. Flint glass re-cycling of this magnitude will require efficient, large scale color sorting techniques; or more practically, the acceptance of color sorted, curb-side re-cycling of container glass. Consumers Glass is actively investigating both options.

The Company anticipates a continued growth in post-consumer cullet availability for the following reasons:

a) The glass container industry has recognized the need for re-cycling programs and is actively engaged in encouraging their development and growth.

b) Environmental pressures will strengthen bottle return legislation in U.S. jurisdictions adjacent to Canadian plant locations.

c) The automotive and construction sectors will remain strong, providing large volumes of scrap plate and sheet glass.
d) Market entry of one trip beverage containers and encapsulated containers in Canadian Provinces will be conditional on container manufacturers meeting specific re-cycling objectives.
e) Returns from industrial and commercial container glass users will improve as solid waste disposal costs and social awareness increase.
f) The public service will increase its internal re-cycling practices.
g) Government funding for 're-cycling societies' and other voluntary groups will increase.
h) Curb-side re-cycling will become a component of an increasing number of municipal garbage removal contracts.

By the year 1987, Consumers Glass anticipates that, at least, 60% of its colored glass production will be produced from re-cycled cullet. This will see selected colored glass furnaces operating at average re-cycled cullet ratios in excess of 70% of the total glass weight. As nominally 10% of container glass batch contains 'in-house' cullet, batch cullet ratios will exceed 80% in some cases.

To aid in the identification and selection of suitable cullet sources, foreign cullet is characterized using a system as outlined in Table 1.

TABLE 1—Foreign Cullet Categories

Class	Single Color	Mixed Color	Free From Contaminants	Bottle Caps and Label Contaminants	Mixed Contaminants	Known Composition	Unknown Composition	Stable Composition
A	X		X			X		X
B	X		X				X	X
C		X	X			X		
D		X	X				X	
E	X			X		X		X
F	X			X			X	X
G		X		X		X		
H		X		X			X	
I	X				X		X	
J		X			X		X	

Cullet types 'A' through 'D' are virtually free of contamination; and although they range from color sorted to completely color mixed, no beneficiation other than cullet crushing is economically justified. Depending on the degree of color mixing and inhomogeneity, separate batch plant storage and weighing facilities are often justified. This range of cullet quality is typical of that returned from customers' filling lines, some re-cycling centres (which clean cullet before returning) and, of course, cullet generated in the glass container plant itself (known as 'in-house' or 'factory' cullet).

Cullet grades 'E' through 'H' are found to contain only metal caps and

foil as contaminants. Varying degrees of color sorting and chemical homogeneity are defined. These are typical of cullet returned under bottle deposit laws and from re-cycling depots. Although virtually free of refractory contamination, the metals must be removed prior to use. Again, segregated batch plant storage and weighing facilities are warranted in some instances.

The final two categories, 'J' and 'K', require substantial beneficiation prior to use, as the 'mixed' contamination usually includes refractory materials such as procelain, whiteware and clay brick. Separate storage and weighing facilities are considered necessary for these types of cullet.

To be considered for categories 'A' through 'D', which are those requiring only crushing and possible separate batch plant handling, a post-consumer cullet must meet the minimum quality criteria detailed in Table 2. In practice, the majority of cullet must be of better quality than this guideline to ensure problem free operation. When experience indicates, even with beneficiation, a cullet cannot be brought within this minimum specification on an on-going basis, the supply is abandoned.

TABLE 2

C R I T E R I A	TOLERABLE LEVEL IN PROCESSED CULLET
Refractory materials	No piece greater than 1 mm^3.
Metals (closures, foil labels, tramp metal)	No piece greater than 10 g in weight. No more than 20 g per tonne of cullet.
Paper, plastics, wood, rags, other organics)	No piece greater than 10 cm^2. Less than 100 g per tonne of cullet. Does not cause jam ups of cullet handling system.
Size (after crushing)*	No piece greater than 3 cm in any direction. No piece greater than 8 cm^3. Thickness less than 10 mm.

NOTE: Crushing of cullet is not permitted if the cullet requires beneficiation at a cullet up-grading facility. Only clean, contamination free cullet is to be crushed before delivery to the glass factory.

Variation in chemical composition of post-consumer cullet is to be expected. Table 3 outlines this Company's specifications and ranges of composition found in practice.

TABLE 3—Postconsumer Cullet Composition Parameters (In Percent by Weight)

	Specified Range or Limit	Amber	Emerald Green	Flint	Plate
SiO_2	68-74	71.4 to 73.2	71.5 to 73.1	71.6 to 74.3	72.9 to 73.2
R_2O	13-16	13.5 to 15.1	13.7 to 14.9	13.0 to 14.7	13.7 to 14.0
RO	10-13	7.6 to 11.3	10.3 to 11.0	10.2 to 11.6	12.4 to 12.6
Al_2O_3	0-3	1.3 to 2.4	1.6 to 2.0	1.5 to 2.3	0.16 to 0.21
B_2O_3	0.5	Not Detected	Not Detected	Not Detected	Not Detected
Fe_2O_3	0.5	0.22 to 0.46	0.12 to 0.20	0.03 to 0.10	0.09 to 0.55
Density Range		2.4990 to 2.5140	2.4985 to 2.5180	2.4880 to 2.5120	2.4932 to 2.4991
Net		0.0150	0.0195	0.0240	0.0059

The impact on glass properties resulting from these wide composition ranges can be minimized in several ways. Blending is the most obvious procedure. At plants where large post-consumer cullet volumes are used, a combination of segregated concrete bunkers and batch plant silo storage is employed. Storage capacities in excess of ten days' usage is desirable. It is preferable to keep the factory cullet separate from foreign cullet. A segregated factory cullet storage system ensures that a supply of clean cullet of stable and known composition is available at all times. This is particularly important when glass problems occur and the foreign cullet is suspected. With separate factory cullet storage, the foreign cullet can be removed and replaced with cullet of known composition and quality. This has been found to greatly facilitate the trouble shooting process.

When a foreign cullet source is of a known and stable composition, separate storage and weighing facilities allow it to be included in the batch calculation procedure. A weight is determined which yields the desired target glass composition. The foreign cullet is thus treated as another raw material.

Including a cullet in the batch calculation procedure can have several advantages. For example, nearly all post-consumer cullet sources have average alkali contents higher than those used at Consumers Glass. Thus batch formulae, which include foreign cullet in the calculation, require less expensive soda ash than the virgin batch does and result in cost savings. Also, a stable foreign cullet composition and a fixed batch weight result in stable glass properties making composition control and trouble shooting procedures more effective.

Blending and segregated storage have been shown as effective means of minimizing the impact of chemical inhomogeneity on glass quality. Homogeneity is also affected by the glass type and its final sizing. Although plate and sheet glass have been successfully used in container glass production, excessively thick plate glass did cause cord in one instance. The thickness of

plate cullet is now specified at less than 10 mm to ensure effective crushing of the material.

Several researches (7, 8) report increased chemical inhomogeneity when borosilicates or lead crystal glass cullets were added to container glass compositions. For these reasons, cullet sources of this type are not permitted.

Other (5, 7, 8) researchers have found a decrease in melting rate and homogeneity as cullet size decreases. Melting rate is said to be adversely affected by the preferential reaction of batch alkali sources with fine cullet instead of with the sand grains. Unmelted batch stones are the suspected result. It is claimed that a deliberately coarse cullet minimizes this problem. The practice of charging cullet seaparately and on top of the batch materials is another reported solution.

Other researchers (9) have observed that cullet can improve glass homogeneity. When cullet was added to a batch composed of raw materials with mismatched grain size distributions, the final glass had improved homogeneity.

Apart from problems in crushing and blending thick plate glass cullet, no other significant incidents have been experienced on the furnaces under study at Consumers Glass. No relationship has been observed between cullet sizing and melting rate. The separation of the cullet and batch handling systems is seen to be advantageous, but for reasons other than concern for cord in glass.

Cullet selection, suitable stock-piling, crusher selection and the process of beneficiation minimize the effect of foreign cullet on glass homogeneity. However, cullet contaminated by metals, refractories, paper and plastic requires more sophisticated up-grading procedures.

BENEFICIATION OF POST-CONSUMER CULLET:

Three general cullet beneficiation formats have been explored. They are: optical sorting, froth flotation and mechanical separation. Briefly, post-consumer cullet can become contaminated with a wide assortment of undersirable materials. The quantity and type of contamination usually depends on where in the waste streams the glass is collected and segregated for re-use by the container manufacturer.

Glass rejected in the container manufacturer's factory is typically clean, color sorted and completely compatible with his batching systems. Cullet collected at a bottling plant may contain caps and labels; but, likely, is in reasonably clean condition. Containers which have been discarded in the household garbage are contaminated with a wide assortment of household wastes and are, virtually, unacceptable for re-use. Even glass which has been segregated by the home owner is rarely color sorted and nearly always contains caps, labels and neck rings. In some cases, scrap ceramic materials, metals, plastics and paper are returned with this post-consumer cullet. This practice is nearly impossible to police, and represents one of the greatest commercial risks to the glass container manufacturer.

Each of the aforementioned beneficiation procedures is more or less efficient in producing a usable grade of cullet. Although extensive experimentation has been conducted on optical sorting techniques, its ability to reduce non-glass contaminants and to produce a color sorted glass product is, as yet, unsubstantiated. This has led Consumers Glass to abandon optical sorting technologies in the short term. The literature (5, 6, 7) confirms that similar conclusions have been reached by other glass container companies.

Froth flotation has been successfully used in ore extraction operations for many years. Research (10) has been done on a color mixed ground glass fraction

from Municipal waste. Although significant up-grading was achieved, the final product was not considered commercially acceptable. In addition, recent studies (8, 9) suggest the finer cullet sizing required by the froth flotation procedure may not be desirable at higher cullet usage levels.

Mechanical beneficiation has been adopted by Consumers Glass and by a number of other container manufacturers (4, 6, 11, 12) as the most practical means developed to date. Figure 1 portrays a typical mechanical beneficiation system, which is seen to include: a feed hopper, dust extraction, magnetic extraction, vacuum extraction, water wash, hand picking stations, rotary cage impact crusher and screening.

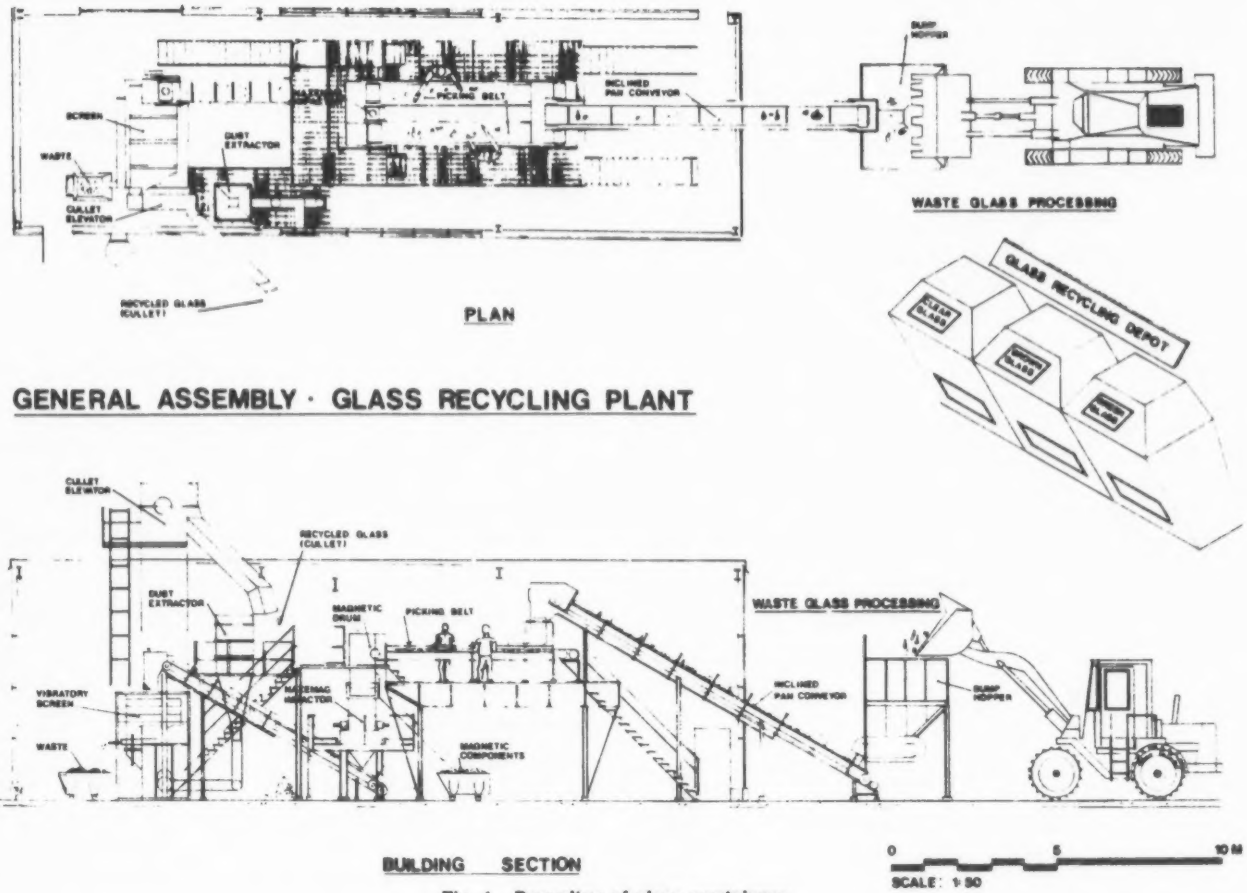

Fig. 1—Recycling of glass containers.

The system will efficiently separate metal caps, neck rings, tramp ferrous metal, paper and plastic labels from the re-cycled glass. The efficiency for removal of other contaminants, particularly ceramics, is highly dependant on the incoming size of such contamination and the diligency of the worker(s) at the hand picking station.

Consumers Glass has operating experience on two mechanical beneficiation systems. In practice, only a very low level of incoming ceramic contamination is tolerable. The ceramic contamination is usually in the form of china tableware, whiteware, porcelain and clay pots. The resistance of china cups, saucers and plates to the rigors of the glass furnace is amazing. It is not unusual to have a piece of this type of ceramic survive the melting process intact enough that the manufacturer's label can still be read in the glazing.

Of course, the problem would be less severe if these contaminants did survive the preparation process intact. Then only one defect would result from each piece. Unfortunately, cullet crushing and batch mixing shatter each large piece into many smaller ones. This increase in the sources of defects continues as containers having large ceramic inclusions are inadvertantly rejected to the factory cullet system. Upon crushing, numerous additional porcelain contaminants are created. This experience suggests that, even with beneficiation available, post-consumer cullet must be relatively free of ceramic contamination and carefully segregated to be successfully re-used in large quantities.

Metal can be efficiently removed by mechanical beneficiation. Magnetic separation is effective for ferrous metal contamination. The non-ferrous metals, particularly aluminum caps and neck rings (18), are removed by a combination of vacuum extraction and screening. This is accomplished by crushing the cullet into a controlled size range using a rotary cage impact crusher. While efficiently fracturing glass pieces, this type of crusher does not significantly deform the metal caps and neck rings. The metal pieces then form the coarse fraction of the crushed product.

The degree of size control exhibited by this type of crusher is detailed in Table 4. This size control permits screening (in this case on 0.625 inches) of the crusher product with only a minimum of product loss, yet with a very high removal efficiency for the metal pieces. Screening also removes larger pieces of plastic and foil. The finer fraction is controlled to 5 to 11% of product passing through a U.S. 16 mesh screen. Water is added to the crushed feed to minimize dusting in handling and storage.

TABLE 4—Comparison of Size Distribution of Two Crusher Products

Approximate		Range of Percent by Weight Crushed Cullet Passing Through the Indicated Screen Size	
		Crusher Type	
mm	U.S. Mesh	Rotary Cage	Jaw
12.5	½ inch	92 to 96	30 to 50
2.5	8	8 to 18	4 to 12
1.25	16	5 to 11	1 to 6
0.25	60	0.5 to 2	0.5 to 1

The dust extraction system is, at present, primarily a worker health consideration. It does, however, remove a portion of the paper, plastics and light metals. As plastic encapsulation of glass containers has become a more significant feature of the Canadian market, it is expected that vacuum extraction will

play a greater role in the beneficiation process.

Beneficiation equipment is expensive, costing approximately $900,000. to install and between $8. and $14. per ton of product to operate. Large, secure cullet volumes are needed to justify this expenditure. Given suitable cullet volumes, the payback, in final glass quality, is significant.

The production on one furnace was monitored for six months before and after all foreign cullet was beneficiated. Before beneficiation, between 20 and 50 machine hours per month were lost to solid inclusions (stones) in the glass containers of the type originating from re-cycled cullet contamination. After beneficiation, no downtime for this source was reported. In fact, no downtime at all was reported for any form of glass melting problems.

This does not suggest that beneficiation alone will eliminate all melting problems; but it does demonstrate that, at least in this case, the contamination in foreign cullet was responsible for a significant portion of the historical stone problems. A comparison of the two six month periods indicates that percent pack improved by slightly over 1% after beneficiation was introduced.

Another significant benefit of an effective foreign cullet beneficiation process is the removal of contaminants potentially harmful to the furnace refractories. Studies in the laboratory at Consumers Glass have demonstrated the extremely corrosive nature of lead and tin on refractories commonly used for furnace bottom paving. The effects of iron and steel are already well known. Reports of damage caused by brass and nickel alloys circulate within the industry.

Examination of the waste material from beneficiation confirms the presence of a wide assortment of metal articles. These include: sledge hammer heads, pieces of angle iron, brass candlesticks, floor grating, welding rods and the like. The presence of these items further highlights the need for adequate beneficiation of foreign cullet. It is obvious that the potential benefits of recycled cullet usage are quickly lost if, through its use, a furnace is lost by glass leaking through a hole in its bottom.

One last identified advantage of effective beneficiation is the increased chemical homogeneity of the resultant product. During the trial period discussed previously, furnace glass density results were compared for the six months before and after foreign cullet beneficiation was employed. Table 5 compares the standard deviation values through the trial and indicates a significant improvement in density control after beneficiation was commenced. This improvement occurred through a period when the range of cullet ratios used was wider than in the pre-beneficiation period.

TABLE 5—Comparison of Standard Deviations in Density Values of a Container Glass

	Before Beneficiation		After Beneficiation	
	$\bar{X}$	S.D. (N-1)	$\bar{X}$	S.D (N-1)
Foreign Cullet Percent by Weight	28.4	4.7	25.8	6.4
Glass density (g/cc)	2.5022	0.0011	2.5014	0.0005

The process of mechanical cullet beneficiation is thus seen to:

-Significantly reduce defects in the glass container originating from contamination in the foreign cullet;

-Minimize the risk of damage to the furnace paving from metallic contaminants in the foreign cullet; and
-Improve the chemical homogeneity of the furnace glass through increased blending of the foreign cullet.

These advantages permit the glass technologist to exploit significantly higher foreign cullet ratios than would otherwise be possible.

OPERATIONAL CONSIDERATIONS:

The literature contains references to certain changes in furnace operating characteristics when the total cullet, expressed as a percent of glass weight, increases. The most obvious is a shortening of the batch line. This has led some container manufacturers to employ lower superstructure temperature or to expect higher production rates at high cullet ratios.

As reported by others (7), Consumers Glass has observed that increased cullet ratios in furnaces without electric boosting result in a reduction in the furnace bottom temperature as measured at the throat. This occurs in spite of constant furnace pulls and superstructure temperatures. Any reduction in superstructure temperature results in further reductions in throat temperatures.

Should the furnace throat temperature fall too low, melting problems can be anticipated. It is, therefore, recommended that the bottom glass temperature be carefully monitored as adjustments to furnace energy and temperature control points are made.

Electrically boosted furnaces do not exhibit significant changes in bottom temperature with changes in cullet ratio. This permits the furnace operator to maximize reductions in overhead firing on electrically boosted tanks and thus improve overall energy efficiency.

Energy savings of 1 to 5% for every 10% of cullet used are reported in the literature (4, 6, 7, 11, 13). Consumers Glass has observed energy savings of this order at cullet ratios above 20%. However, why the savings at any given cullet ratio vary from furnace to furnace requires further evaluation.

The energy consumption of three colored glass furnaces, which were all electrically boosted and operating in the 120 to 170 tonnes per day range was evaluated as the cullet ratios varied between 20 and 55%. In all cases, energy per unit of glass melted decreased as cullet levels increased. However, the amount of energy saved varied from a low of 1.2% per 10% cullet increase to a high of 4.4%. Studies on other furnaces indicate that maximum energy savings occur on large capacity, deep, well insulated glass furnaces equipped with electric boosting.

The furnaces studied all melted colored glass (Emerald green or amber) at cullet ratios above 20%. Suitable volumes of flint cullet are not readily obtained, thus similar studies on a flint glass furnace have not been undertaken.

These evaluations suggest that one tonne of cullet saves about 30 cubic meters of natural gas. This is at the lower end of the values reported in the literature (4, 6, 7, 13), which range from 35 to 40 cubic meters of natural gas saved per tonne of cullet used. One U.S. glass container manufacturer (13) states that a savings of 3.8×10^6 litres of oil would result from a cullet usage of 60% in the production of 181,000 tonnes of container glass. Although direct comparisons of this sort are difficult, as initial furnace efficiences and final glass quality are not available for review, it is apparent that substantial energy savings can result from higher cullet usage levels.

At the higher cullet usage levels, reductions in furnace superstructure

temperatures are possible, particularly on electrically boosted furnaces. Experience indicates that at cullet usage above the 20% level, a 5°C superstructure temperature reduction for each further 10% cullet increase is possible. Lower operating temperatures are said to increase furnace refractory life and reduce environmental emissions.

Owens-Illinois, Inc. (6) assumes a one year increase in furnace life at high cullet ratios. Consumers Glass does not anticipate a similar benefit as its furnace lifetimes already approach 14 years.

Reductions in furnace emissions are predicted by several published (14, 15, 16) relationships between furnace superstructure temperature and pollution emission rates. Higher cullet usage, which permits lower operating temperatures, will thus lead to reduced emissions.

This Company's experience confirms savings in melt energy and reductions in furnace operating temperatures follow increases in cullet usage. It is assumed that reductions in furnace emissions follow reductions in superstructure temperature. Based upon current operating practices at Consumers Glass, no significant increase in furnace life is anticipated. Current economic condtions have not warranted furnace capacity increases, thus the effect of high cullet ratios on furnace capacity have not been studied.

DESIGN CONSIDERATIONS:

An ideal re-cycled cullet usage program requires:

-Color sorted cullet.
-Cullet sources virtually free of refractory contaminants.
-Suitably sized on-site cullet storage.
-A well supervised beneficiation system.
-Segregated product storage and weighing facilities.
-Electrically boosted furnaces.
-Careful post-forming quality control.

Design needs to allow for, at least, ten days' storage of incoming cullet and five days' storage of beneficiated product. Stock-piling of this sort averages out cullet usage levels and provides a more homogeneous product. Consumers Glass has in excess of 6,000 tonnes of cullet storage in Ontario and 4,000 tonnes in Quebec. Stock-piling needs have taxed these capacities on several occasions.

The cullet beneficiation system should operate only while supervision is on site. Capacity should be established to permit a one-shift operation five days per week. Surges can be accommodated by overtime. After beneficiation, the product needs to be stored in enclosed storage.

A means of separately transporting and proportioning cullet to the furnace is said (7, 8) to have several advantages. It saves wear and tear on the conventional batching system. The raw material batch size can be fixed whilst cullet weights fluctuate independently of the conventional batch weighing system constraints. Such a system could be designed to discharge cullet on top of the batch blanket. This is said (7, 8) to minimize carry-over and maximize the chemical homogeneity of the glass.

Currently Consumers Glass does not handle cullet independently of the raw material batch. All ingredients are weighed, mixed and conveyed to the furnace as one batch. At cullet ratios up to 80%, no abnormal melting problems or batch equipment wear has been noted. However, batch size, and thus scale weight changes are often required to accommodate cullet ratio changes. Separate cullet conveying and charging systems would only be considered where installation costs are modest.

Combined with these design considerations is the need for tight supervision and constrol. Experience suggests that large scale re-cycled cullet use at a few locations is preferable to lower utilization at many locations. The use of even small quantities of foreign cullet increases the complexity of the batch and furnace operation substantially.

CONCLUSIONS:

Acceptable quality post-consumer cullet can be advantageously incorporated into the glass container manufacturing process. Supplies of suitable foreign cullet are not abundant and must be encouraged. Competition for these sources will be keen.

Although not achieving all its proponents claim, raw material cost savings, melt energy efficiency improvements and reduced operating temperatures do result from cullet usage above 20%. Reduced glass furnace pollution emissions are expected to result from increased cullet usage. Increased furnace lifetimes and higher outputs have yet to be investigated.

Suitable glass quality and preservation of furnace refractories do result from the well supervised mechanical beneficiation of foreign cullet. Separate foreign cullet storage and proportioning systems and the use of electric boosting are seen to maximize the benefits of high cullet ratios. Separate handling and charging systems would be considered if costs were modest.

The glass container industry has become more and more confident in its ability to select and use post-consumer cullet. Much more information will likely emerge in the short term. It is suspected this will further enhance foreign cullet's position as a suitable glass making raw material.

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MONITORING FOR POTENTIAL CONTAMINATION FROM TWO ABANDONED LANDFILLS NEAR SAINT JOHN, NEW BRUNSWICK

by Norman C. Gridley[1], Harold LeBlanc[2], and Owen V. Washburn[3]

1.0 INTRODUCTION

Over the past several years, the Province of New Brunswick and Environment Canada have been involved in a cost-shared series of investigations dealing with abandoned land disposal sites in New Brunswick. This program has been conducted in three Phases. Phase I, completed in 1982, identified 190 closed or abandoned sites in the Province. Phase II followed with investigations of high priority sites. The work being reported here is Phase III of the federal/provincial abandoned landfill program in New Brunswick.

Completed in 1983, Phase II involved the primary investigation of six sites which were considered to be of high priority. Factors which were investigated were waste type, waste site structure and design, leachate composition and production rate, leachate seeps and the potential for contamination of nearby ground and surface waters. Three of the six sites investigated during Phase II were recommended for further study. Two of these sites were the Howes Lake and French Village sites near Saint John.

The Phase III work (Washburn & Gillis Associates Ltd. and Nolan, Davis & Associates Ltd., 1986) consisted of more detailed ground and surface water investigations at the Howes Lake and the French Village Abandoned Landfill Sites. The study objectives were to establish in more detail the nature of organic and inorganic contamination leaving these sites, to address the implications of contamination migration from the site, and, where appropiate, to propose remedial action. Field work began in March 1984 and was completed in December 1985. At the Howes Lake site both ground and surface water investigations were undertaken. At the French Village site the work focused on groundwater investigations with very limited sampling of surface waters.

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2.0 DESCRIPTION OF THE STUDY AREAS

2.1 Howes Lake Site

The Howes Lake abandoned landfill site is located within the City of Saint John approximately four kilometres north of the center of the city, between Sandy Point Road and University Avenue (Figure 1). Since the study was completed, an arterial highway has been built through part of the landfill site.

Landfill operations began at the Howes Lake site in the early 1950's. The site initially encompassed 1 hectare but expanded to 22 hectares by the time it was closed and capped in 1978. The waste pile thickness varies over the site with the greatest accumulation (approximately 25 m) occuring near the centre of the site. Both domestic and industrial waste were deposited in the site. It was estimated that 483,000 tonnes of wastes were landfilled (Water Management Services Limited, 1983).

The site is located in a relatively high topographic area which is oriented north-south. The site consists of a flat central area bordered to the north and south by two topographically higher, but parallel ridges. The northwestern topographic high slopes somewhat steeply toward University Avenue, while the southeastern high parallels and dips steeply toward the Sandy Point Road. Elevation differences of up to approximately 60 m exist between adjacent on-and off-site areas. Topographic gradients range from 0.12 to 0.2 on the western and eastern portions (respectively) of the site and adjacent areas.

The till veneer at the Howes Lake site is a discontinuous medium brown morainal till. It consists of silty sand with abundant cobbles and boulders. It rarely exceeds 1.5 m thickness, except in locally developed depressions or abrupt discontinuities in the underlying bedrock. Bedrock exposures are common and extensive throughout the site, especially in the northeast corner.

The Saint John area is underlain by an assortment of igneous and sedimentary rock units which are distributed in northeasterly trending belts, following the general structural grain of the Appalachian Uplands of southern New Brunswick. The rocks range in age from Late Precambrian sediments and intrusives to Mississippian and Triassic sedimentary rocks.

The rocks in the vicinity of the Howes Lake landfill site fall into three main divisions. The central and southern portion of the site is underlain by the oldest rocks in the area, the Green Head Group of Late Precambrian (probably Helikian) age (Currie, 1984). The Green Head Group comprises a succession of platformal carbonates, quartzites, and shales which were deposited on older basement rocks. The rocks encountered in Boreholes 2, 3A and 3B (quartzite and argillite), and 4 (dolomite) belong to the Green Head Group of sediments.

The second rock unit in the area is the Golden Grove Suite of igneous intrusives and metamorphic rocks. These rocks are also Late Precambrian

(probably Hadrynian) age (ibid.). This suite includes gneisses, mafic intrusives and granitic rocks (McCutcheon and Ruitenberg, 1984). It occupies a northeasterly trending belt approximately 1 km wide just south of the landfill site. Mafic dykes commonly occur around the borders of these intrusive bodies. A small lenticular mafic body intrudes the Green Head sediments just north of the landfill site, and its southern border is coincident with the edge of Howes Lake. This unit is mapped (ibid.) as a distinct and younger Precambrian unit named the Milkish Head granodiorite. It includes a quartz diorite phase, which was encountered in Boreholes 1A and 1B.

The third group of rocks at the Howes Lake site is the Mississippian Kennebecasis Formation. This unit includes a maroon colored conglomerate, sandstone, mudstone, and nodular limestone (ibid.). The maroon conglomerate outcrops along University Avenue. The contact between the Kennebecasis Formation, the Green Head sediments and Milkish Head intrusives, approximately follows University Avenue. The dolomitic limestone encountered in Borehole 5 probably belongs to the Kennebecasis Formation, although it is very close to the contact with the Green Head sediments and may be a member of this Group.

The geology of the Saint John area is structurally very complex. Many of the Precambrian rocks have been subjected to at least three phases of deformation (Nance, 1982). Although the structural geology of the area has received increased attention recently, it is still not well understood.

A major northeast trending fault separates the Precambrian Green Head sediments and Golden Grove intrusives from the Upper Precambrian volcanics to the south. Extensive strike slip may have occurred along this fault as many rock units are truncated against it (Ruitenberg et al., 1979). This northeasterly trend is repeated in numerous other fault lines and lineations in the regions, which define the tectonic grain of the area. Small grabens, formed at right angles to the major northeasterly transform faults, may explain the occurrence of numerous northwesterly trending faults and fractures (Currie, 1984).

Local surface water drainage consists of small streams. The site is drained by two watercourses: a tributary of Alder Brook and a brook draining Howes Lake (named Howes Lake Brook). Alder Brook drains the abandoned landfill site in a westerly direction, passing along the north side of an apartment complex before discharging to the main Alder Brook channel which flows along University Avenue. Alder Brook then passes under University Avenue via a culvert and flows into Kennebecasis Bay, about 1 kilometre downstream.

Howes Lake is situated to the northeast of the abandoned landfill site and portions of the site drain to it. Howes Lake Brook flows along Sandy Point Road and is augmented along this route by several other drainage courses. Eventually Howes Lake Brook enters a storm drain which passes near Hazen White and St. Francis Schools. Flow from this storm drain discharges ultimately to the Saint John River near Indiantown.

2.2 French Village Site

The French Village site is located approximately 3 kilometres southwest of the village of Quispamsis, approximately 20 km northeast of the centre of the City of Saint John. It is accessible by a dirt road from Highway 860 (Figure 2).

Landfilling began in 1957 at the French Village site in a former sand and gravel quarry. Prior to 1984 the site was operated as an area dump with regular burning. Subsequently, the site has been operated as a landfill with the regular burial of wastes. It is still being used as a landfill site. The site primarily serves nearby municipal areas although approximately 15 percent of the waste is commercial/industrial. It has been estimated that 220,000 tonnes of waste have been disposed of at the site (Water Management Services Limited, 1983).

The French Village area is blanketed by a morainal till deposit with a locally developed overlying ablation till which contains abundant boulders. This ablation till is largely responsible for the hummocky topography. The till cover at the site varies from 4 to 10 m, with very little bedrock exposure within 1 kilometre of the landfill. The morainal till consists of a dark brown silty sand with abundant cobbles and boulders.

Kames are mapped in the vicinity of the French Village site. A uniform medium grained sand deposit, probably of glaciofluvial origin, occurs within the site. A typical section can be seen in an excavation near drilling Site 3, immediately southwest of the landfill. This sand unit varies in thickness and locally may be 10 to 15 m, or greater.

The French Village landfill site is underlain entirely by Precambrian diorite. The diorite is part of the Golden Grove Suite of intrusive and metamorphic rocks which include gneiss, granite, granodiorite, quartz diorite, and gabbro. The Suite occupies a northeasterly trending belt with an average width of 2 kilometres which coincides with the strongly developed regional tectonic grain of the area.

In the area of the landfill, the dominant regional bedrock structural grain has a northeast-southwest orientation and many small faults follow this orientation. The Golden Grove Suite is also often intruded by highly broken and altered dykes.

The diorite underlying the French Village site is moderately well fractured in the upper 1 to 2 m of the bedrock surface. Most of the fractures are steeply dipping (near vertical) and contain chlorite and quartz, as well as a reddish-brown clay-like material. Sulphide mineralization is also present on some fracture surfaces.

An outcrop of fine-grained diorite on the road just south of the landfill site exhibits a minor joint set striking at 048 Azimuth with dip near vertical to the northwest. The joints are spaced 2 to 4 centimetres and are tight, with an aperture generally less than 2 millimetres; some fractures are clay infilled.

Within these surficial materials streams are not well developed, however a first order stream has its headwaters in the area southwest of the landfill. It eventually drains into MacFarlane Lake.

3.0 METHODOLOGY

3.1 Groundwater Studies at Howes Lake Site

After the site reconnaissance, a program of bedrock structural mapping was undertaken. Samples of on-site surface waters were also taken. These data were used to design the drilling program. A diamond drilling program was developed to install seven boreholes at five sites (Figure 3). With one exception (Site 3) these locations were immediately down flow gradient of the landfill. Two boreholes were drilled at Sites 1 and 3. Boreholes 3A and 3B were drilled through landfilled material. In these boreholes rotary drilling was used for initial penetration and to set casing into bedrock prior to borehole completion with a diamond drill. All drilling water was obtained from off-site surface water courses.

Single point piezometers were installed in all boreholes. Five sets of groundwater elevation data were recorded for each piezometer from November 1984 through December 1985. Slug tests were performed on all boreholes except 3B to determine the bulk hydraulic conductivity of the bedrock. Both falling and rising head tests were undertaken using the Hvorslev (1951) method. Table 1 summarizes information on the boreholes and presents the hydraulic conductivity values found at the Howes Lake landfill site.

Upon completion of drilling, a period of one and one-half months was allowed to lapse prior to sampling to ensure that the piezometer tips self flushed by the natural movement of groundwater. Samples were then taken from each piezometer in October 1984 and June, August and December 1985. Three domestic wells near the landfill site were also sampled in March 1984 and December 1985.

All samples obtained from piezometers were analysed for major ions, organic scan, trace metals, mercury and phenols. The semi-quantitative organic scan technique was developed by Dr. J. Barker (University of Waterloo) and provided an indication of the presence of some halocarbons and aromatic hydrocarbon compounds. One suite of volatile, acid extractable and base extractable organics were analysed from a limited number of piezometer samples.

Field determinations included measurement of groundwater elevation, pH, temperature, alkalinity, and hydrogen sulphide (odour detection).

Samples analysed for major ions and trace metals were field filtered (at 0.45 um) and fixed with concentrated nitric acid. Samples for mercury and phenols were collected in specially prepared bottles containing preservatives. Analyses for these parameters were conducted by the Environmental Chemistry Laboratory in Halifax, Nova Scotia.

TABLE 1. BOREHOLE DATA AT HOWES LAKE SITE

Borehole	Depth of Borehole (m)	Depth to Bedrock (m)	Bedrock Type	Hydraulic Conductivity (cm/s)
1A	9.47	1.27	Quartz Diorite	3.2×10^{-4}
1B	18.51	1.52	Quartz Diorite	1.6×10^{-3}
2	9.30	1.01	Quartzite	6.5×10^{-4}
3A	20.12	9.45	Calcareous Quartzite	3.0 x 10-4
3B	33.58	8.84	Calcareous Quartzite	not available
4	11.73	2.46	Dolomite	3.7×10^{-3}
5	9.50	0.90	Dolomitic Limestone	4.5×10^{-3}

Organic scan samples were collected in specially prepared glass bottles, and were analysed by the Organic Geochemistry Laboratory at the University of Waterloo. Samples analysed for volatile, acid extractable and base extractable organics were also collected in specially prepared glass bottles and the analyses were conducted by Mann Testing Laboratories in Mississauga, Ontario. The organic samples were stored on ice and shipped by air; typically they were received by the laboratory within one day of collection.

3.2 Surface Water Studies at Howes Lake Site

The surface water sampling program at the Howes Lake abandoned landfill site had three primary components: (1) establishment of surface flow measuring weirs at the two watercourses draining the site and measurements of water levels at the weirs; (2) collection of water samples at the weirs and subsequent laboratory analyses; and (3) monitoring of surface flows and rainfall precipitation during one intensive rainfall event. Locations of weirs at the Howes Lake site are shown on Figure 3.

The drainage areas of Alder Brook and Howes Lake Brook upstream of the weirs installed for this study are 19.0 and 22.6 hectares, respectively. The weirs employed were consisted of plywood sheets with 90-degree

notches, installed by hand and reinforced with sandbags. Water levels at the weirs were measured monthly, as opportunities arose, and during an intensive rainfall event in December 1984.

The surface water quality measurement included regular monthly sampling and intensive sampling. The types and times of sampling are given in Table 2. The purpose of monthly and quarterly sampling was to obtain information on the seasonal variability of the contamination potential of surface waters. The sampling during the rainfall event was conducted in order to assess short-term temporal variability in quality. The sampling along Howes Lake Brook and Alder Brook, conducted in late August, was intended to identify the spatial variability in concentrations of organics.

TABLE 2. SURFACE WATER QUALITY SAMPLING PROGRAM AT HOWES LAKE SITE

Frequency	Parameters sampled	Locations
Monthly	Conductivity, metals, DOC, pH, temperature	Alder Brook, Howes Lake Brook
Quarterly	EPA priority organics	Alder Brook, Howes Lake Brook
Once	Major ions, metals, TOC, organic scan, pH, temperature	various seeps near Howes Lake
Over 12 hrs	pH, conductivity	Alder Brook at weir
Once	Organics, metals, DOC, pH, temperature, conductivity	along Alder Brook, along Howes Lake Brook

All surface water quality samples obtained during the study were collected as grab samples. Samples to be analysed for organics were collected in pre-cleaned, sealed glass bottles provided by Mann Testing Laboratories Limited. Samples to be analysed for inorganics were collected in 1-litre plastic bottles, while those to be analysed for metals were collected in 250 mL plastic bottles and fixed with nitric acid in the field. Inorganic and metals determinations were made by K-F Laboratories of Fredericton, New Brunswick and the Environmental Chemistry Laboratory in Halifax, Nova Scotia. Temperature and pH measurements were made in the field.

3.3 Groundwater Studies at French Village Site

Following initial site reconnaissance, surface water and stream geochemistry samples were taken on North and South Streams (Figure 4). A sample was also taken from the closest domestic drilled well to the

site. These samples were analysed to determine whether or not there was evidence of leachate leaving the site. A seven borehole diamond drilling program, at five sites (similar to the Howes Lake drilling program) was carried out in March and April 1984 (Figure 4). All drilling sites were outside the actual landfill area. Two boreholes were completed at Sites 1 and 3. Four boreholes (1A, 2, 3A and 5) only penetrated the overburden. At drilling Site 3, drilling problems associated with the collapse of the highly fractured bedrock necessitated the drilling of a third borehole in August 1984.

At each drilling site slug tests were performed to measure the hydraulic conductivity of the overburden and, in the case of Boreholes 3C and 4, the bedrock. Table 2 presents data on the boreholes at the French Village site. Piezometers were installed at all boreholes and four sets of groundwater elevation measurements were collected.

TABLE 3. BOREHOLE DATA AT FRENCH VILLAGE SITE

Borehole	Depth of Borehole (m)	Depth to Bedrock (m)	Geologic Material Encountered	Hydraulic Conductivity (cm/s)
1A	4.03	*	Silty sand	7.8×10^{-6}
1B	7.16	4.12	Diorite	not available
2	7.97	*	Silty sand	1.4×10^{-4}
3A	5.23	*	Silty sand	6.8 x 10-4
3C	15.70	5.86	Diorite	5.6×10^{-2}
4	12.96	9.75	Diorite	8.7×10^{-4}
5	9.91	*	Silty sand	3.3×10^{-5}

* bedrock not encountered in borehole

Water samples were taken in August 1984 from all piezometers and analysed for major ions, organic scan, metals, mercury and phenols. Field determinations consisted of groundwater elevation, pH, temperature, alkalinity, and hydrogen sulphide (odour detection).

The analytical methods employed were the same as those for the Howes Lake Site.

4.0 FINDINGS

4.1 Groundwater Studies at Howes Lake Site

Groundwater quality data were obtained from three types of sources at the Howes Lake site: piezometers, domestic wells, and leachate springs/seeps. The findings from sampling of each type of source are subsequently discussed.

4.1.1 Piezometer Sample Analyses for Major Ions and Metals

Seven piezometers installed throughout the site were generally sampled four times each over an approximate one year period. Figures 5, 6, 7 and 8 illustrate the results for major ions. Major ion chemistry data showed that the site groundwaters are calcium bicarbonate type waters, with the exception of piezometer 1A (shallow piezometer) which was a calcium chloride type water. This exception is probably attributable to nearby road salting which is seasonally flushed through the shallow groundwater flow system.

The seven piezometers provided samples from depths ranging from 9.47 to 33.6 metres. The greatest seasonal variation in total ion concentrations was found associated with the shallow piezometers. The deeper piezometer samples showed less seasonal variability, generally within a range of 1 milliequivalent per litre (meq/L) in total ion concentrations.

The groundwater quality data showed that concentrations of major ions were quite low as compared to concentration ranges normally associated with landfill leachates. With the exception of one chloride analysis, all major ions were found to be within the maximum acceptable concentration limits of the Canadian Drinking Water Quality Guidelines (Health and Welfare Canada, 1979). All trace metals were found to be within the maximum acceptable concentration limits. Some trace metals (e.g., aluminum, iron and manganese) showed significant seasonal variability. The iron and manganese values often exceeded the maximum acceptable concentration limits.

Water quality from piezometer 1B (depth, 18.51 m) was considered uncontaminated, while water quality from all other piezometers showed evidence of leachate contamination. Piezometer 3B (depth, 33.6 m) showed that leachate had extended to at least this depth. Vertical flow gradients between piezometers 3A and 3B suggest that leachate contamination may extend to significantly greater depths.

Generally, the leachate increased alkalinity, TDS, TOC, calcium, sodium, iron and manganese values in affected groundwaters.

4.1.2 Domestic Well Sample Analyses for Major Ions and Metals

Three homes immediately adjacent to the Howes Lake abandoned landfill site are dependent upon groundwater. These wells were sampled twice, once in March 1984 and again in December 1985. Major ion data showed

that two of the wells have a calcium bicarbonate type water, while the third has a sodium bicarbonate type water (Figure 9).

Water quality analyses for two of the three wells showed that quality parameters were within maximum acceptable concentrations, with the exception of iron values, and are generally representative of background groundwater quality. Water quality analyses for the third well displayed evidence of deteriorated quality. Unfortunately, although the third well was sampled twice, the results are not comparable because the original well was replaced following a house fire. The original well had a calcium chloride type water, with very high values for sodium, calcium, sulfate, chloride and TDS, which were indicative of contamination. The new well has a calcium bicarbonate type water, and has elevated values for sodium, sulfate, potassium and TOC. The most likely sources of this contamination are either landfill leachate or Howes Lake.

4.1.3 Analyses of Leachate Springs and Seepages for Major Ions and Metals

A number of leachate springs and seepages were sampled in and around the Howes Lake site. Figure 10 illustrates the results of sample analyses for major ions. All of these leachate features can be classified as calcium bicarbonate type waters with major ion concentrations similar to results obtained from piezometers 2, 3A, 3B and 4. Major ion concentrations are quite low for landfill leachate type samples; however, alkalinity, ammonia, TOC, TDS, iron and manganese values are all in excess of the maximum acceptable concentrations for drinking water.

4.1.4 Analyses of Groundwaters for Organics

Qualitative analyses of volatile aromatic hydrocarbons and volatile halogenated hydrocarbons (halocarbons) were employed, as well as quantitative analyses of volatile and solvent-extractable organics. The qualitative (organic scan) analyses were used to provide an indication of the approximate level of leachate contamination, while the quantitative analyses were intended to precisely identify the concentrations of the organic contaminants detected.

The qualitative organic scan analyses provided only slight evidence of leachate effects by aromatic hydrocarbons at piezometers 3A, 3B, 4 and 5. Only the May 1985 samples displayed significant (i.e. 30 to approximately 75 ug/L) of total aromatics including benzene, toluene, ethylbenzene and cumane. Subsequent samples indicated that aromatic levels were much lower (i.e. less than 10 ug/L). Although traces (i.e. less than 0.5 ug/L) of halocarbons were found in the December 1985 samples, no other evidence of halocarbons was found. The halocarbons detected included chloroform, trichloroethylene, 1,1,1-trichloroethane and carbon tetrachloride.

The quantitative volatile and acid-base extractable organic analyses of EPA priority pollutants provided no evidence of significant leachate effect on the groundwaters sampled. Piezometer 5 contained no

detectable volatiles; piezometer 4 contained traces (i.e. less than 0.5 ug/L) of benzene and toluene; and piezometer 3B contained 0.7 ug/L of benzene, 2.0 ug/L of toluene and a trace of dichlorobenzene. For those piezometers sampled, the non-volatile extractable analyses indicated the presence of di-N-butyl phthalate (5.3 to 13.4 ug/L for piezometers 1B and 2, respectively) and bis(2-ethyl hexyl) phthalate (11.6 to 24.9 ug/L for piezometers 3B and 1B, respectively. Cresol, a phenolic compound, was present at 50 ug/L in piezometer 3B. In addition 1.5 ug/L of 1,4-dichlorobenzene (piezometer 1B) and traces of both diethyl phthalate (piezometers 1B, 2 and 3B) and phenol (piezometers 1B and 3B) were detected.

The absence of a broad range of organics, and the documented ability of both phthalates and cresols to leach from PVC compounds (of which the piexometers were constructed) substantiated the conclusion that there was limited effect of leachate on the groundwaters sampled.

4.2 Surface Water Studies at Howes Lake

4.2.1 Hydrologic Response and Potential Leachate Production

Weir measurements were obtained at the two watercourses draining the landfill site during all ice-free months of the year. Information on regional runoff was also investigated, as well as the results of monitoring for a single rainfall event in December 1984. These sources of data were used in order to estimate mean monthly flows at each weir site.

Monitoring of the rainfall event showed the response of the two small watersheds to be rapid, although only a small percentage of the rainfall discharged from the watersheds as direct runoff. At the Alder Brook weir, 6.5% of the rainfall volume was discharged as direct runoff. At the Howes Lake Brook weir, the value was 2.1%. These low percentages would be due partly to the dry period preceding the rainfall event; the storage effect of Howes Lake would also tend to cause a low value at the Howes Lake Brook weir.

On average, the ratio of runoff to precipitation in the Alder Brook and Howes Lake Brook drainage areas is likely between 25 and 50%, meaning that 50 to 75% of the precipitation falling upon the abandoned landfill site infiltrates downward, becoming groundwater which potentially could contact leachate.

4.2.2 Surface Water Quality Investigations for Inorganics and Metals

Seasonal sampling for inorganics and metals in surface waters showed that Alder Brook and Howes Lake Brook are contaminated, having elevated levels of conductivity, ammonia and DOC. However, no seasonal trend was evident. The levels were not indicative of gross contamination of surface waters. Within sixteen surface water samples, conductivity values ranged from 665 to 1160 umho/cm, while DOC ranged from 9.2 to 18.5 mg/L.

Surface water quality sampling during the rainfall event of December 1984 showed that contaminant loading rates increased during the rainfall event. Loading rates were at a maximum near the peak of the discharge hydrograph, and they dropped to levels similar, but in excess of, pre-rainfall rates.

4.2.3 Surface Water Quality Investigations for Organics

Samples were obtained quarterly from surface water at the Alder Brook weir and were quantitatively analysed for organics. Additionally, during the summer sampling (August 1984) two additional samples were obtained further upstream in Alder Brook (closer to the landfill). The analytical results showed that most compounds detected were present at concentrations much less than 10 ug/l (usually less than 5 ug/L) or at trace levels. The six isolated exceptions to this were all measured in samples obtained at the Alder Brook weir: bis(2-ethylhexyl)phthalate (22.4 ug/L and 234 ug/L in December and April 1984, respectively); dichloromethane (29.3 ug/L in October 1984); diethyl ether (613 ug/L in December 1984); hexane (over 500 ug/L in December 1984); and phenol (13.9 ug/L in October 1984). Given the lack of occurrence of a wide range of organics at significant concentrations, it was concluded that organic compounds in surface waters were not considered to be an environmental concern.

The spatial variability of organics as measured by three samples taken at points along Alder Brook suggested that there may be some natural attenuation in concentrations of organic compounds in the downstream direction. However, the data showed that all concentrations were very low, with all except one reading being less than 10 ug/L.

4.3 Groundwater Studies at French Village Site

4.3.1 Analyses for Major Ions and Metals

All piezometers at the French Village Site were sampled in August 1984 for major ions, trace metals and physical inorganics. Analytical results showed that all of the groundwaters can be classified as calcium bicarbonate type waters (Figure 11).

Because of its position upgradient of the landfill, the groundwater chemistry data obtained from piezometer 5 are considered representative of the silty sandy overburden at the site. The low TDS and conductivity values are indicative of a shallow and short groundwater flow system. Data from piezometer 3A indicate that leachate contamination is present in the overburden immediately southwest of the landfill. Data from piezometer 3B, within the diorite bedrock, provide no indication of leachate contamination.

The trace metal data for all groundwater samples show no significant effect on groundwater quality from the landfill. Most values, except manganese, are within maximum acceptable concentration limits.

4.3.2 Analyses of Groundwaters for Organics

Qualitative (i.e. organic scan) analyses for halocarbons and aromatic hydrocarbons were undertaken for site groundwaters (and selected surface waters) in order to indicate the general type and level of volatile organics present. In terms of volatile halocarbons and hydrocarbons, there was no evidence of significant effect of the landfill on ground and surface waters at the site.

5.0 ENVIRONMENTAL IMPLICATIONS

5.1 Howes Lake Site

Surface water investigations at the Howes Lake site showed that the small streams draining the area are slightly contaminated. No seasonal trend in inorganic contamination was evident. Metal contamination was not an environmental concern. Organic compounds were present in surface waters at levels generally less than 10 ug/L, suggesting that contamination had occurred but not at a gross level.

Remedial action suggested for this site centers around the provision of means to prevent human access to areas of open surface waters.

Surface runoff measurements for the site showed that the mean annual runoff could be on the order of 25 to 50% of the mean annual precipitation. Therefore, it is evident that a significant percentage of the average annual precipitation may potentially move into the ground and could eventually become contaminated.

Groundwater investigations at the Howes Lake site showed the most prominent groundwater flow direction will be off-site toward the southwest; other flow directions will be toward the south, north and northeast. Howes Lake would be the main receptor in the north and northeast flow directions. Leachate from the landfill has penetrated at least 34 m into the fractured bedrock beneath the site, and contamination probably extends beyond this depth. Laterally, leachate probably extends beyond the landfills site, although its migration will be confined to specific fracture flow features.

Inorganic analyses indicated effects of leachate on groundwater quality, but there was no evidence of gross contamination. Two adjacent domestic wells were found to be unaffected by the landfill. A third well displays evidence of contamination, and several potential sources of contamination (including landfill leachate) exist.

Trace organic analyses of groundwater showed that there was little effect of leachate upon the groundwaters sampled at the site. Samples from only one domestic well, downgradient of the site, indicated the possibility of significant halocarbon concentrations.

5.2 French Village Site

Groundwater investigations at this site showed that groundwater movement off-site would be toward the southwest, and possibly the southeast. Movement of leachate appears to be principally confined to the surficial materials, and does not appear to extend beyond the immediate landfill area.

Inorganic analyses suggested that there was evidence of leachate contamination in one of the piezometers installed adjacent to the site, but this contamination was not gross. There was no evidence of leachate impact on domestic wells located east of the landfill.

Trace organic analyses of groundwater indicated no evidence of significant levels of organics in the groundwaters as a result of leachate contamination.

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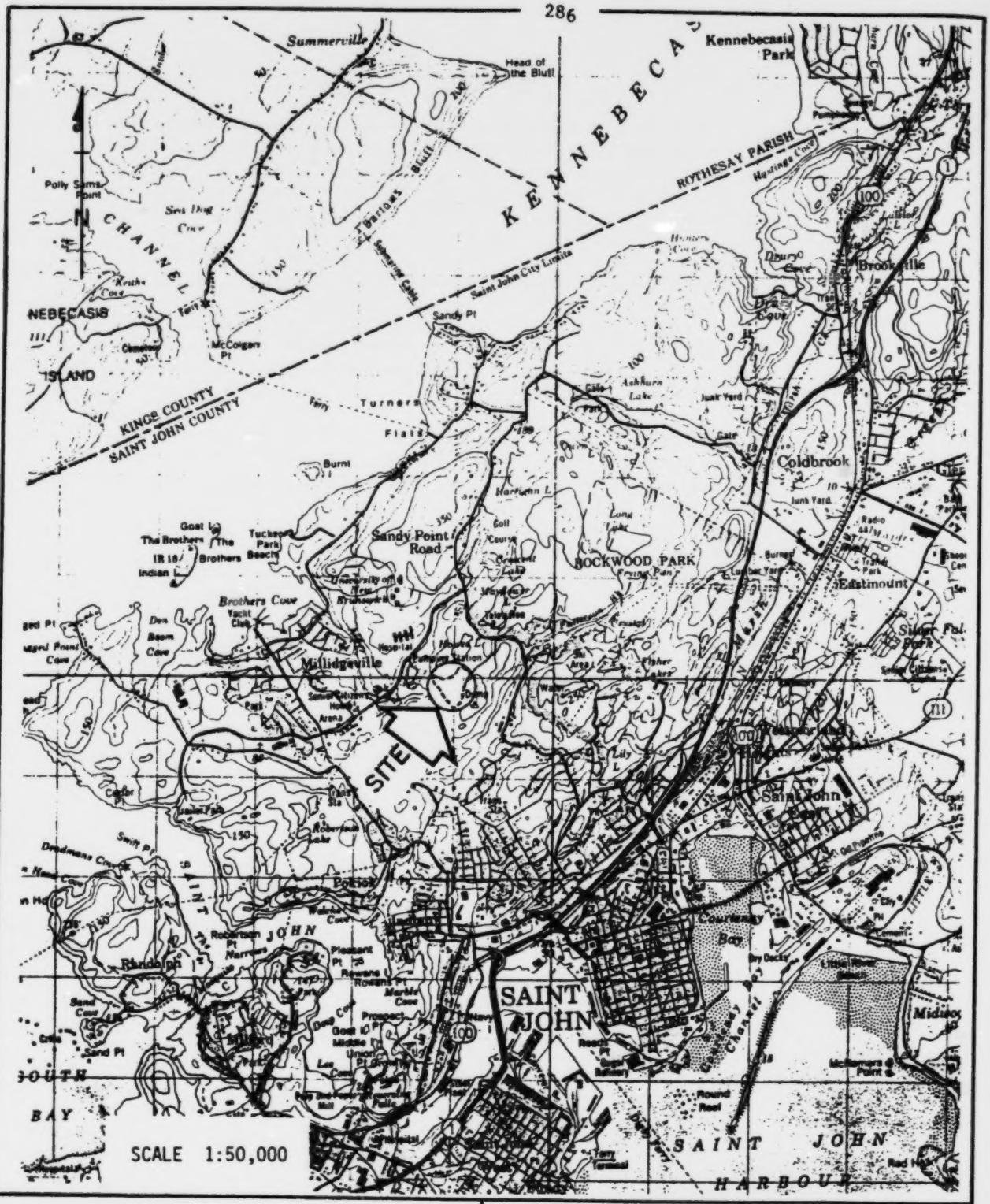
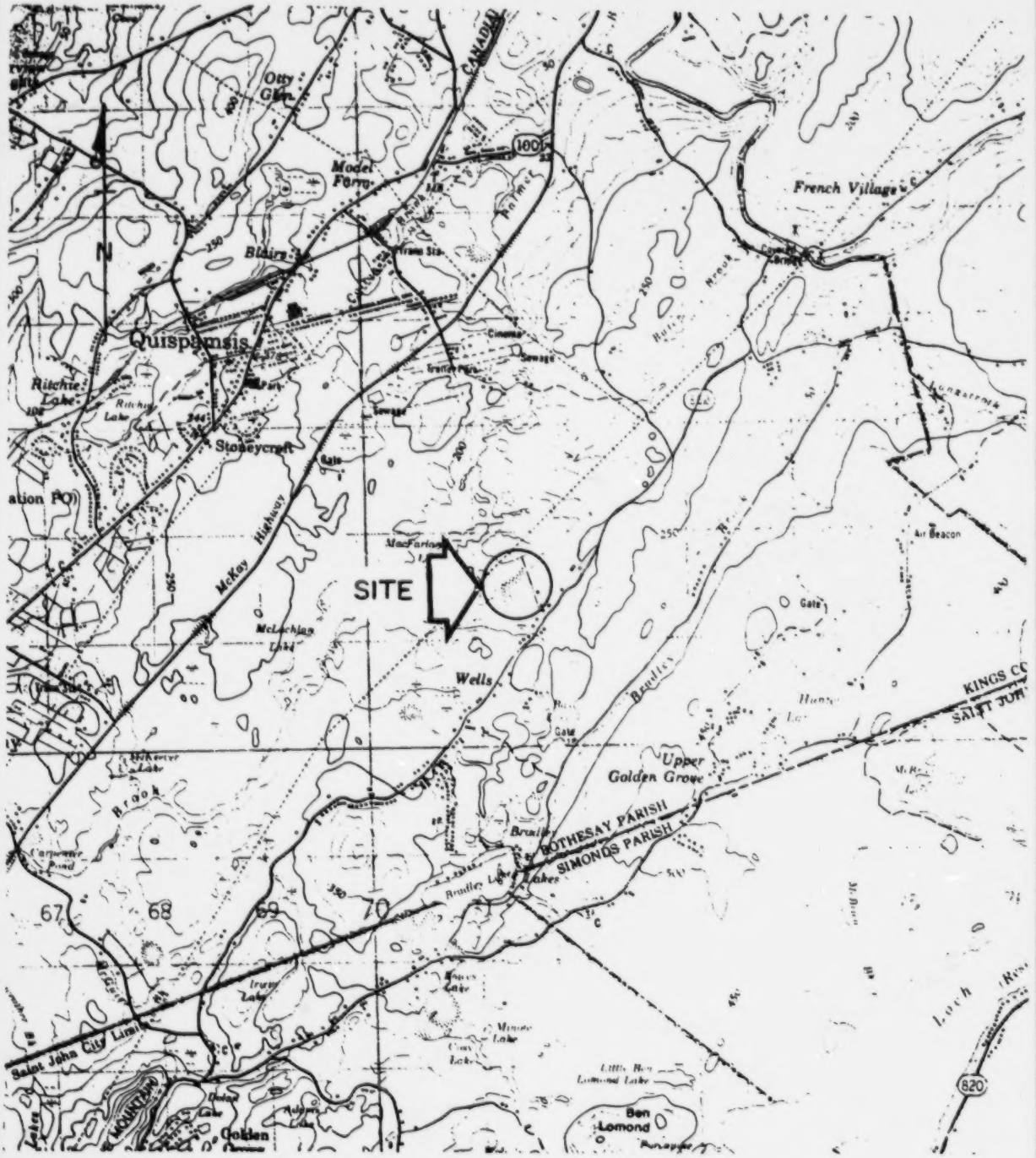

Summerville
Head of the Bluff
Kennebecasis Park
KENNEBECAS
ROTHESAY PARISH
Hastings Cove
Bartlows Bluff
Saint John City Limits
Brookville
Drury Cove
Polly Sums Point
Sans Thief Cove
N CHANNEL
Kruhn Cove
Ferry
NEBECASIS
ISLAND
McColgan Pt
Sandy Pt
Ashburn Lake
Junk Yard
Gate
KINGS COUNTY
SAINT JOHN COUNTY
Turners Flats
Burnt
Coldbrook
Harrison L.
Goat
The Brothers
IR 18
Indian
Tucker Park Beach
Sandy Point Road
Golf Course
ROCKWOOD PARK
Eastmount
Brothers Cove
Yacht Club
Millidgeville
Hospital
SITE
Saint John
Courtenay Bay
Deadmans Creek
Portion
SAINT JOHN
Robertson Pt
Rockwood Park
Rockwood Lake
Rockwood Park Campground
Rockwood Park Golf Course
Rockwood Park Fishing Pond
Rockwood Park Lily L.
Rockwood Park Lost L.
Rockwood Park Trout Park
Rockwood Park Prospect Pt.
Rockwood Park Rowans Pt.
Rockwood Park Marble Cove
Rockwood Park Pleasant Pt.
Rockwood Park Union Pt.
Rockwood Park Middle Pt.
Rockwood Park Goat Pt.
Rockwood Park Lee Cove
Rockwood Park Drake Cove
Rockwood Park Sand Cove
Rockwood Park Sand Pt.
Rockwood Park Cliffs
Rockwood Park Reversing Falls
Rockwood Park Reversing Falls Rapids
Rockwood Park Reversing Falls Bridge
Rockwood Park Reversing Falls Power Station
Rockwood Park Reversing Falls Mill
Rockwood Park Reversing Falls Pulp Mill
Rockwood Park Reversing Falls Paper Mill
Rockwood Park Reversing Falls Sewage Treatment Plant
Rockwood Park Reversing Falls Water Treatment Plant
Rockwood Park Reversing Falls Water Tower
Rockwood Park Reversing Falls Water Reservoir
Rockwood Park Reversing Falls Water Pumping Station
Rockwood Park Reversing Falls Water Filtration Plant
Rockwood Park Reversing Falls Water Intake
Rockwood Park Reversing Falls Water Outfall
Rockwood Park Reversing Falls Water Discharge
Rockwood Park Reversing Falls Water Quality
Rockwood Park Reversing Falls Water Monitoring
Rockwood Park Reversing Falls Water Sampling
Rockwood Park Reversing Falls Water Testing
Rockwood Park Reversing Falls Water Analysis
Rockwood Park Reversing Falls Water Data
Rockwood Park Reversing Falls Water Report
Rockwood Park Reversing Falls Water Study
Rockwood Park Reversing Falls Water Plan
Rockwood Park Reversing Falls Water Management
Rockwood Park Reversing Falls Water Resources
Rockwood Park Reversing Falls Water Supply
Rockwood Park Reversing Falls Water Demand
Rockwood Park Reversing Falls Water Conservation
Rockwood Park Reversing Falls Water Recycling
Rockwood Park Reversing Falls Water Reuse
Rockwood Park Reversing Falls Water Treatment
Rockwood Park Reversing Falls Water Disposal



SCALE 1:50,000

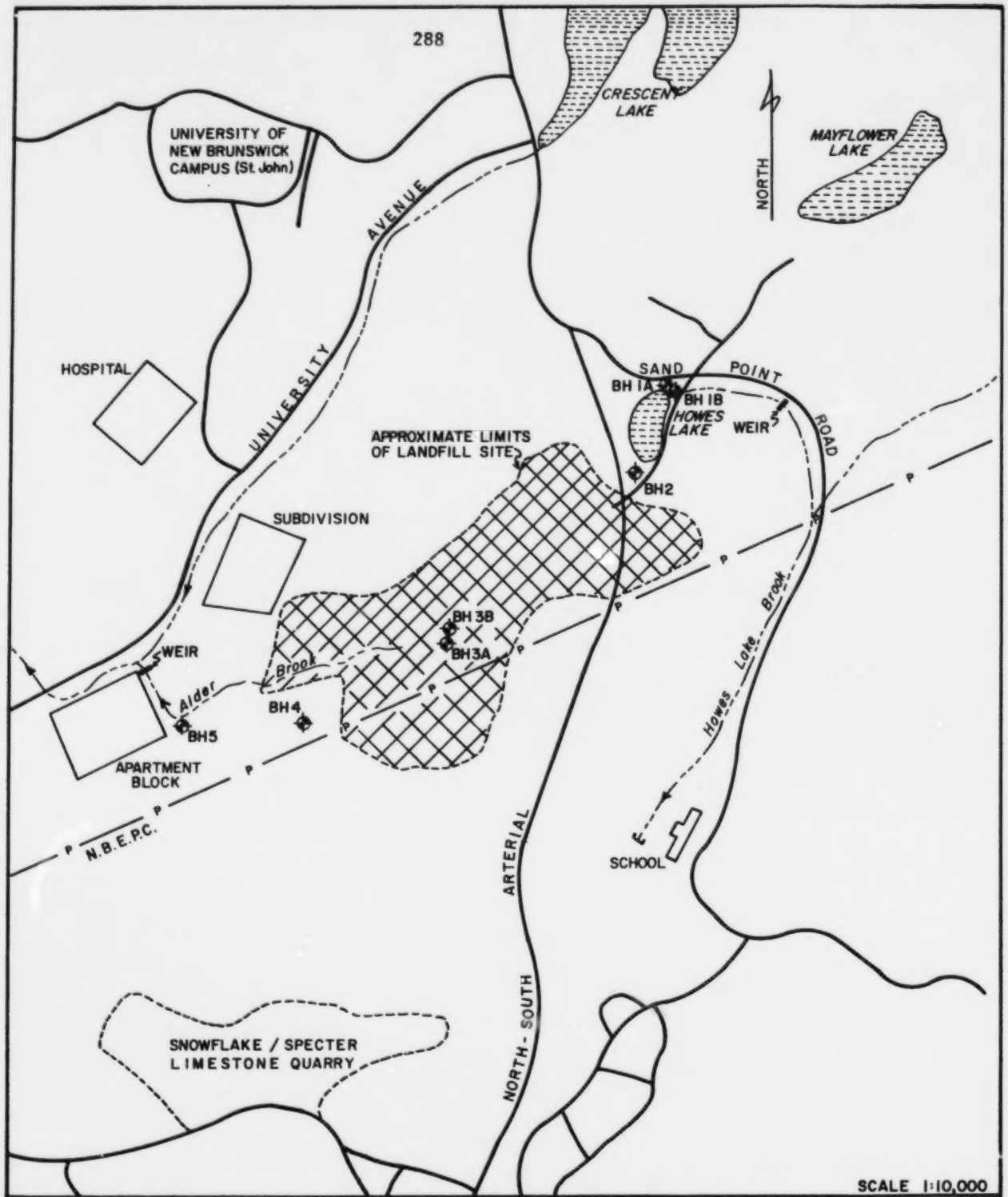
NOLAN, DAVIS & ASSOCIATES

SITE LOCATION: FRENCH VILLAGE

date: SEPTEMBER 1985

project: H84193

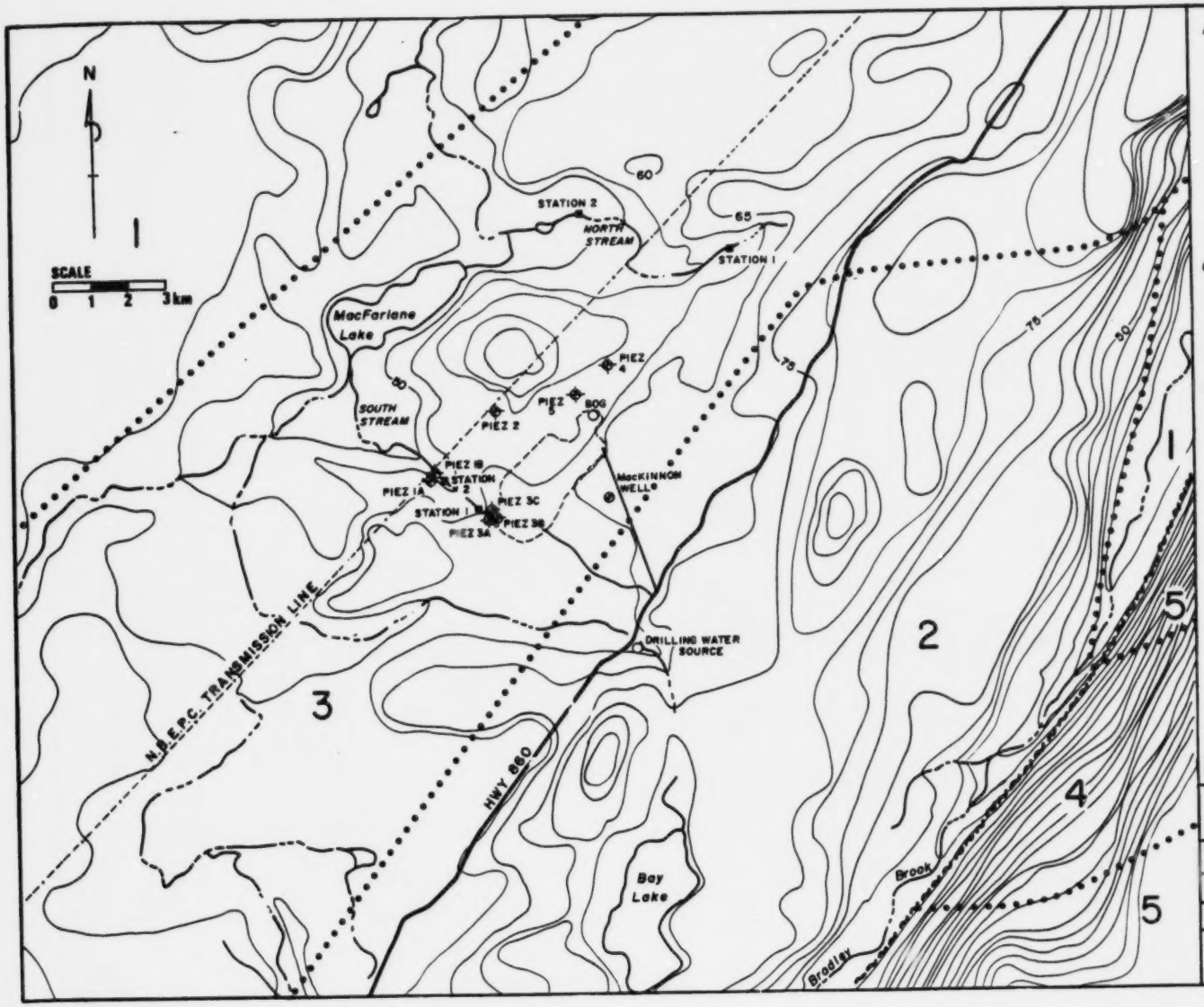
FIGURE 2



NOLAN, DAVIS & ASSOCIATES

FIGURE 3

LOCATIONS OF WEIRS AND BOREHOLES
HOWES LAKE SITE



LEGEND

- GEOLOGICAL BOUNDARY
- FAULT
- BOREHOLE AND PIEZOMETER (NOLAN, DAVIS & ASSOCIATES, 1984)
- DOMESTIC WELL, SAMPLED 1984
- SURFACE WATER, SAMPLED 1984
- SURFACE WATER AND STREAM SEDIMENT GEOCHEMISTRY SAMPLED 1984.

GEOLOGY

PRECAMBRIAN

5 COLD BROOK GROUP AND EQUIVALENTS: Felsic volcanic rocks with minor mafic volcanic rocks; mainly tuffs and locally tuffaceous sandstones and siltstones.

4 Mafic volcanic rocks with minor felsic volcanic rocks; mainly flows.

PRECAMBRIAN AND PALEOZIC (?)

3 Light to dark-grey-green, grey, fine to medium-grained (in part porphyritic) gabbro and diorite.

2 Light-to-dark-grey paragneiss; red to pink-red granite-gneiss; grey, grey-green, and locally pink, medium-grained granodiorite, quartz diorite and minor diorite; red to pink-red, coarse-grained granite.

GREEN HEAD GROUP:

ASHBURN FORMATION:

1 Blue-grey and white limestone; light-grey to cream dolostone with grey-green to dark-grey argillite, argillaceous quartzite and quartzite.

NOTE: CONTOUR INTERVAL 5 METRES

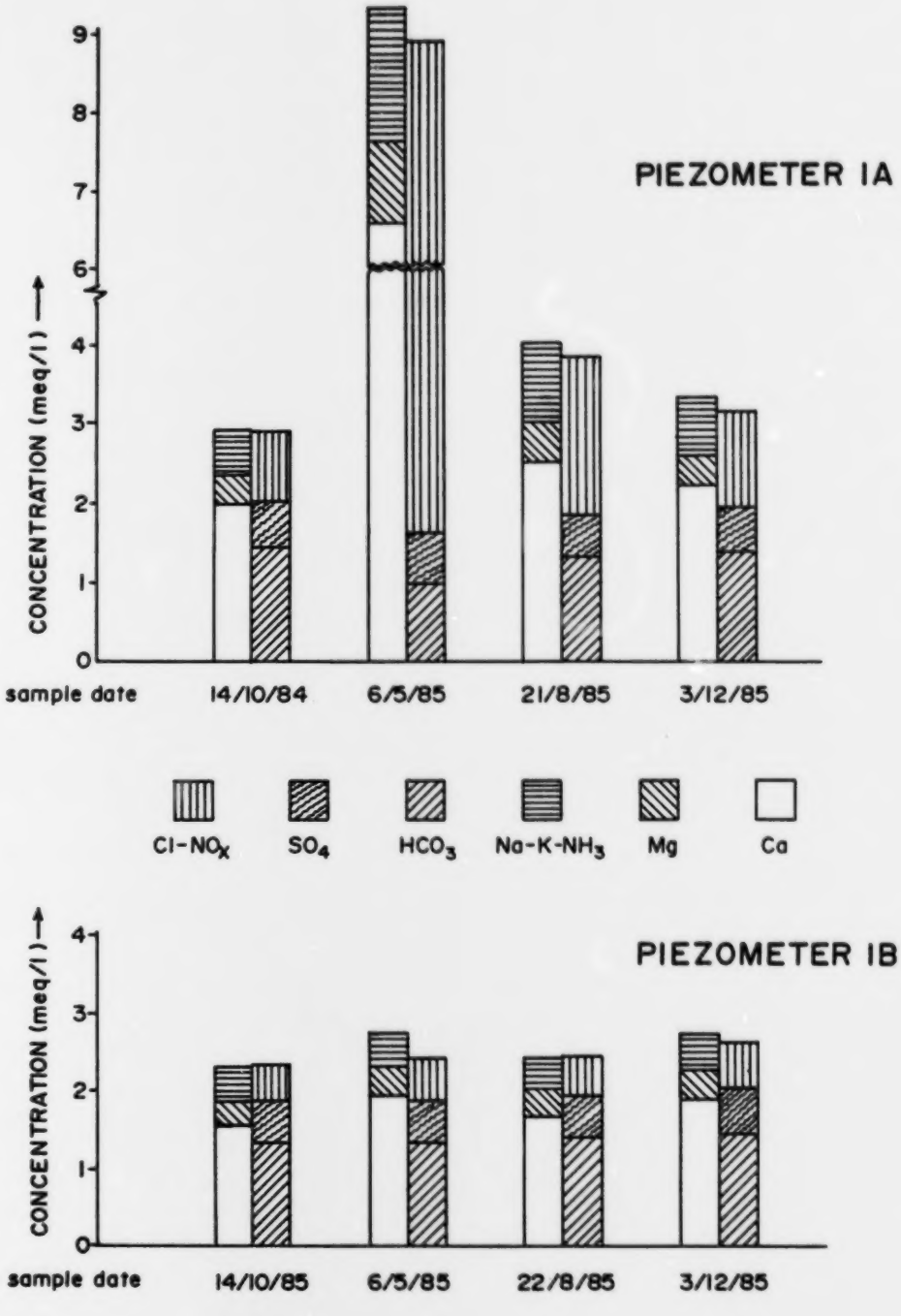
REFERENCE: GEOLOGY AND MINERAL DEPOSITS, CALEDONIA AREA, LOCH LOMOND SHEET (21 H/SW), A.A. RUITENBERG ET. AL., 1975, 1:50,000.

ORTHOPHOTO SHEETS 21H/05-U3 & 21 H/05-U4, SCALE 1:10,000, DATED 1971.

NOLAN, DAVIS & ASSOCIATES

French Village New Brunswick

FIGURE 4



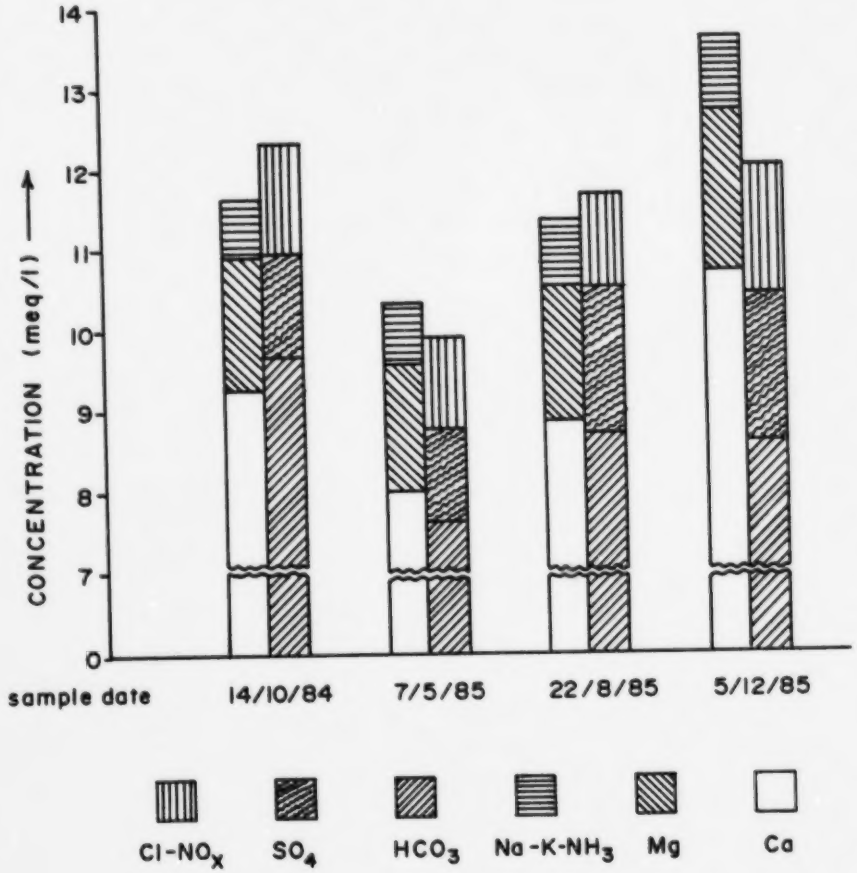
NOLAN, DAVIS & ASSOCIATES

MAJOR ION CHEMISTRY

date: MARCH 1986

project: H84193

FIGURE 5



PIEZOMETER 2

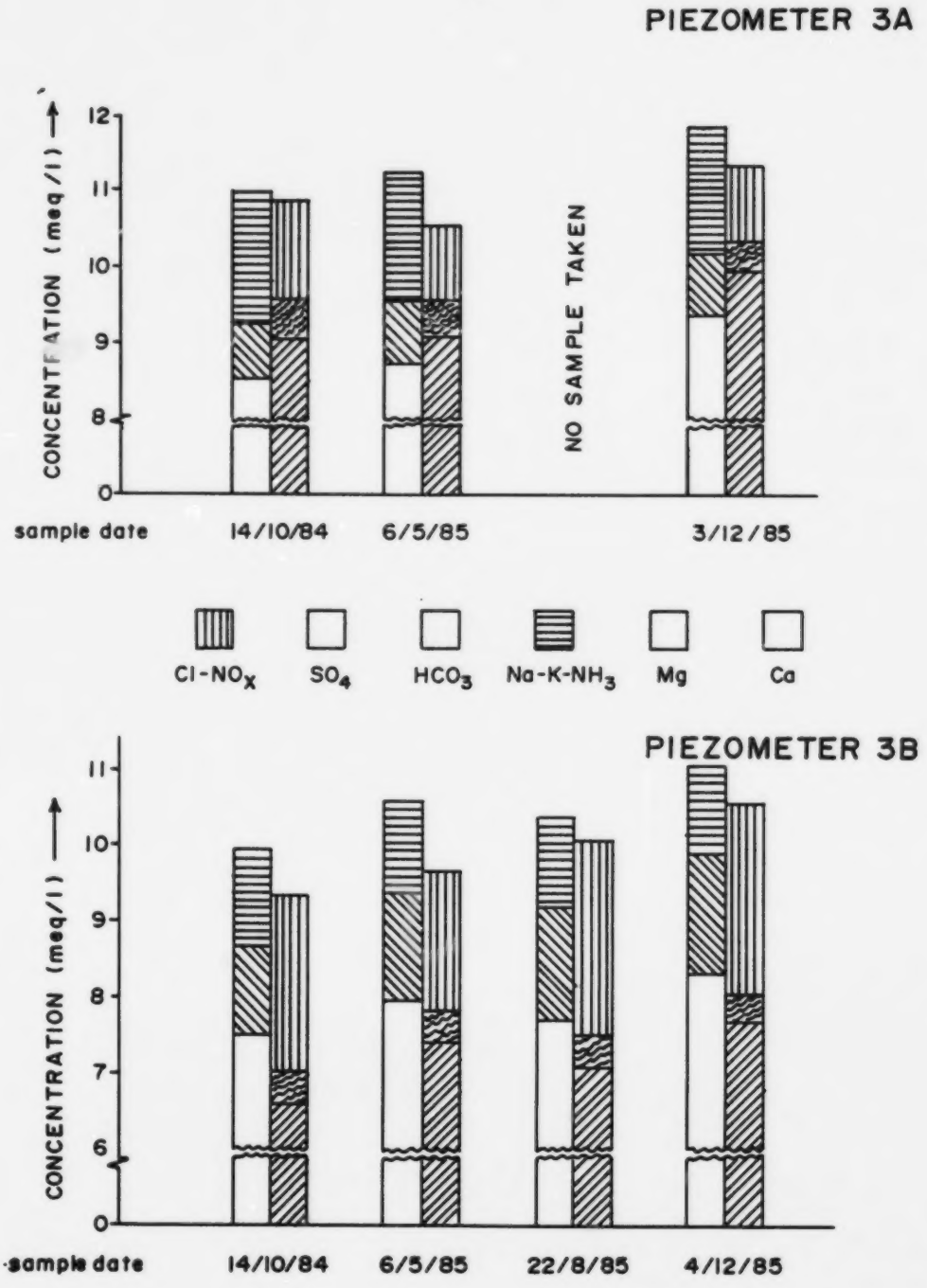
NOLAN, DAVIS & ASSOCIATES

MAJOR ION CHEMISTRY

date: MARCH 1986

project: H84193

FIGURE 6



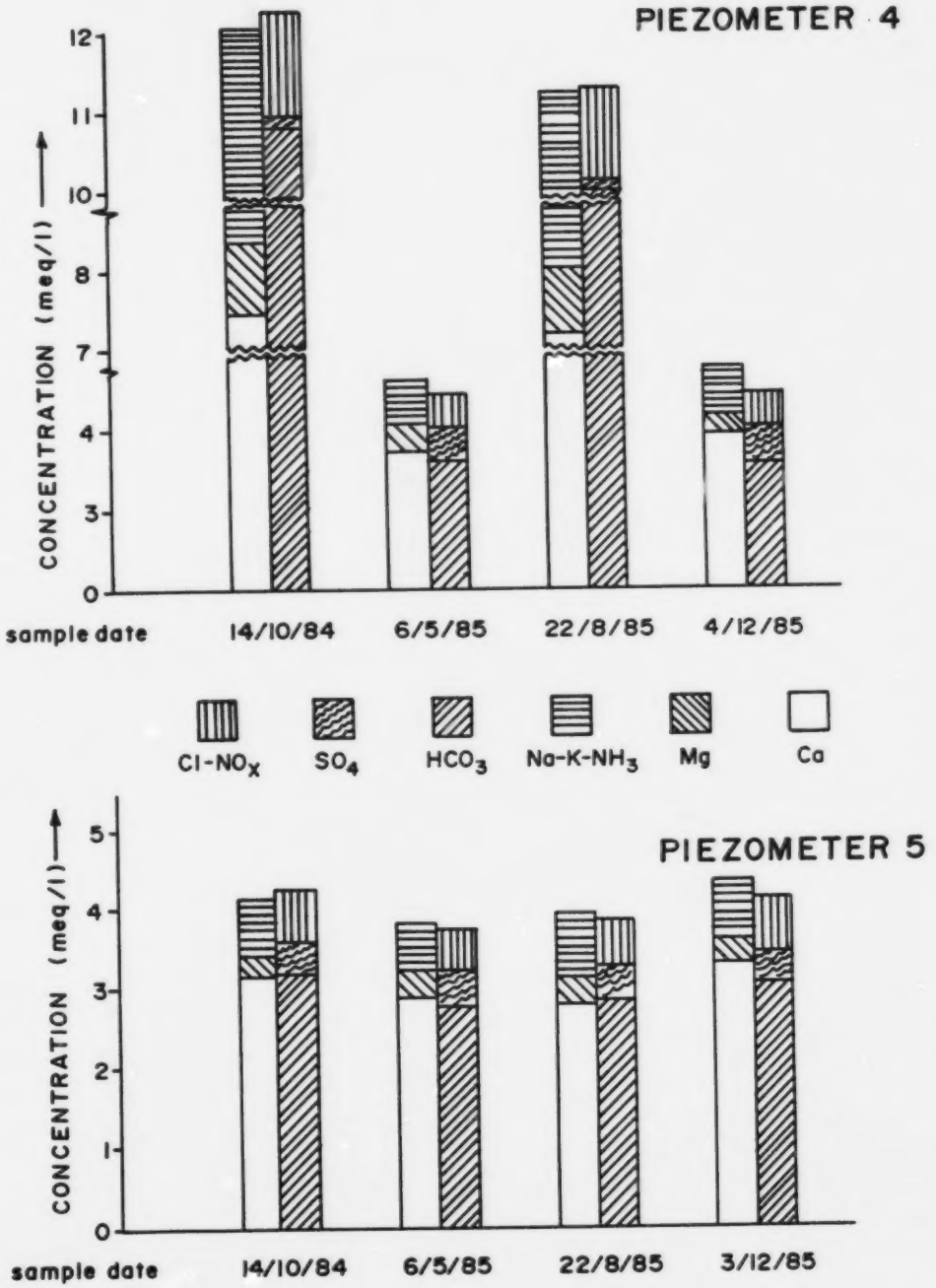
NOLAN, DAVIS & ASSOCIATES

MAJOR ION CHEMISTRY

date: MARCH 1986

project: H84193

FIGURE 7



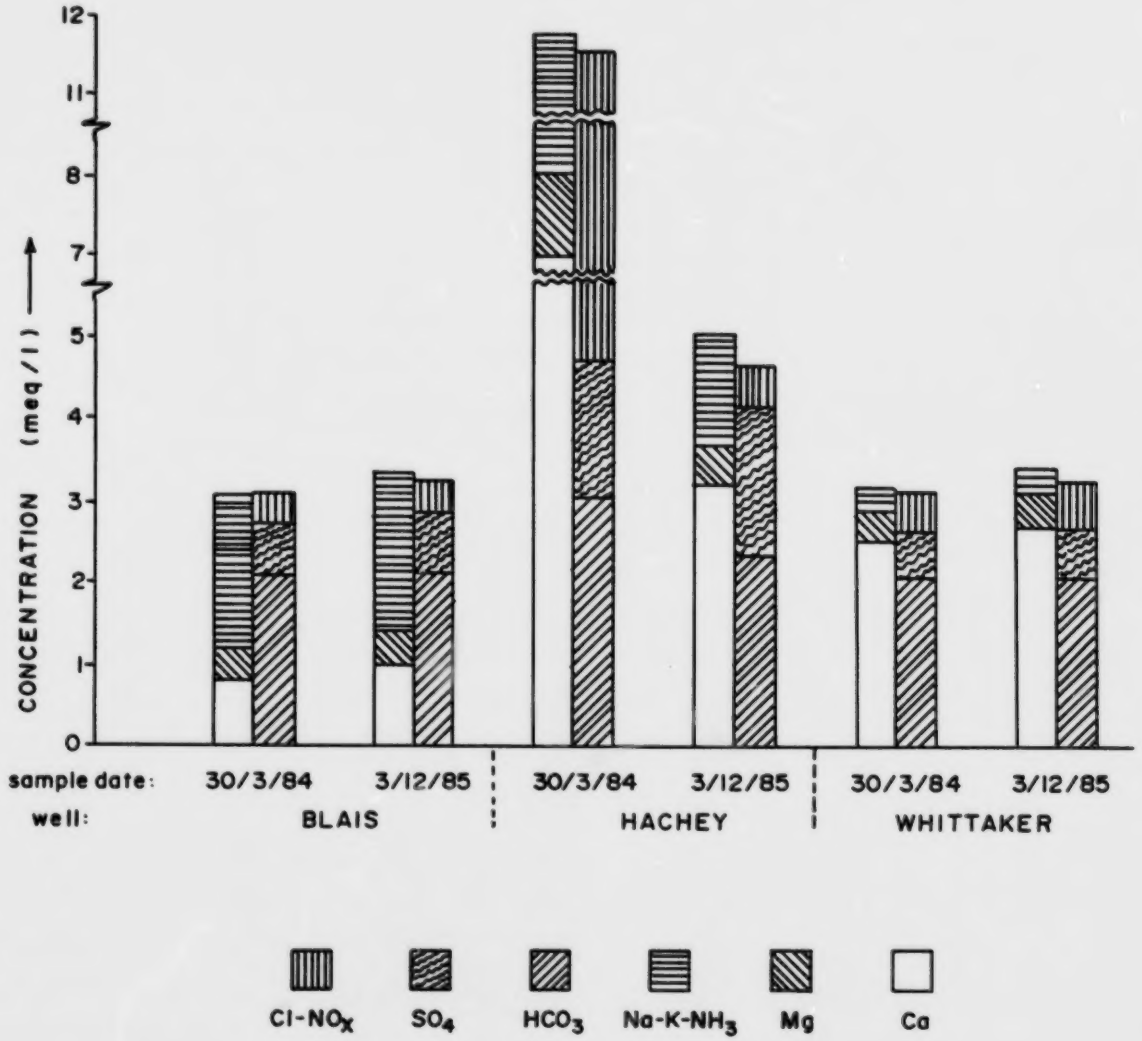
NOLAN, DAVIS & ASSOCIATES

MAJOR ION CHEMISTRY

date: MARCH 1986

project: H84193

FIGURE 8



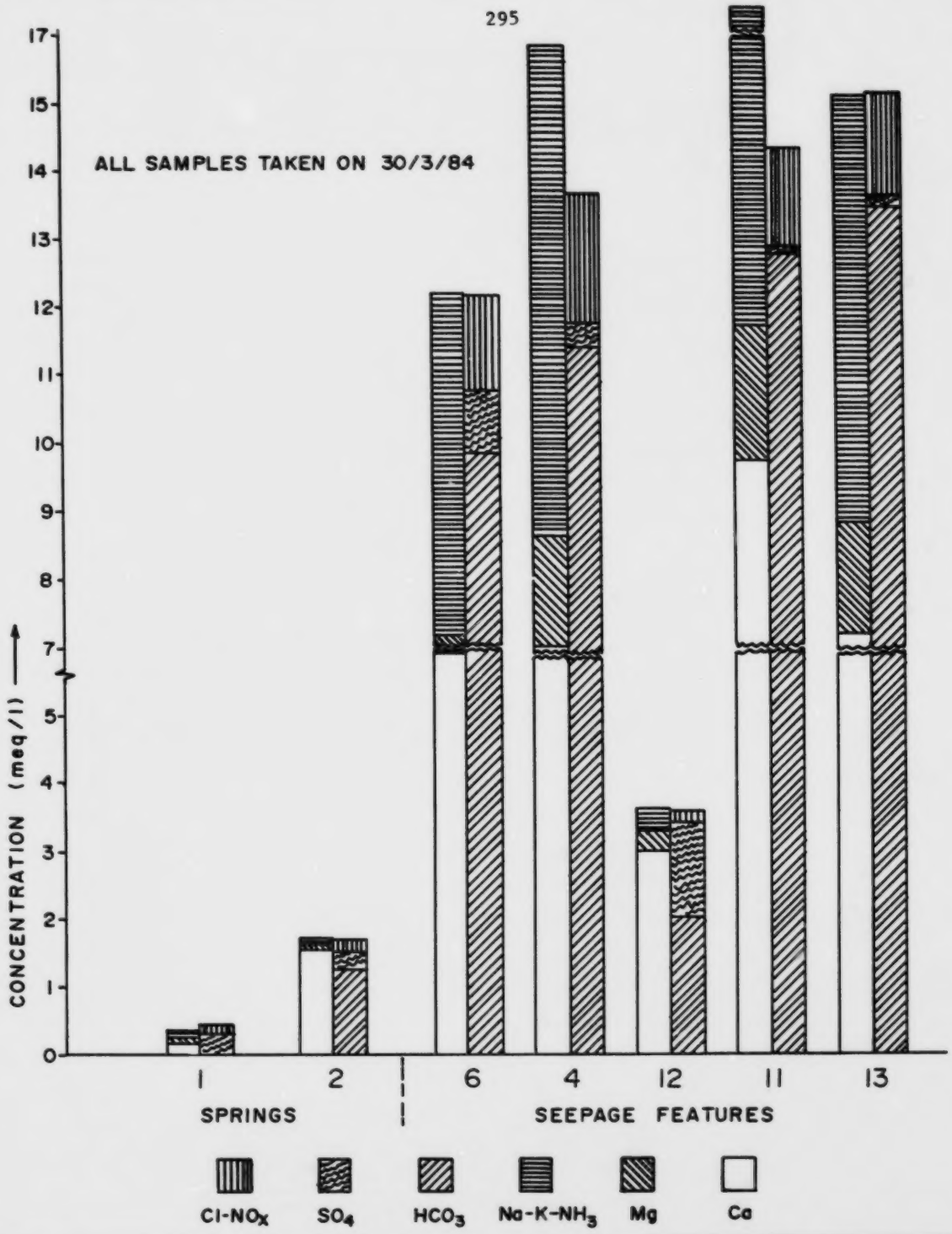
NOLAN, DAVIS & ASSOCIATES

MAJOR ION CHEMISTRY

date: MARCH 1986

project: H84193

FIGURE 9



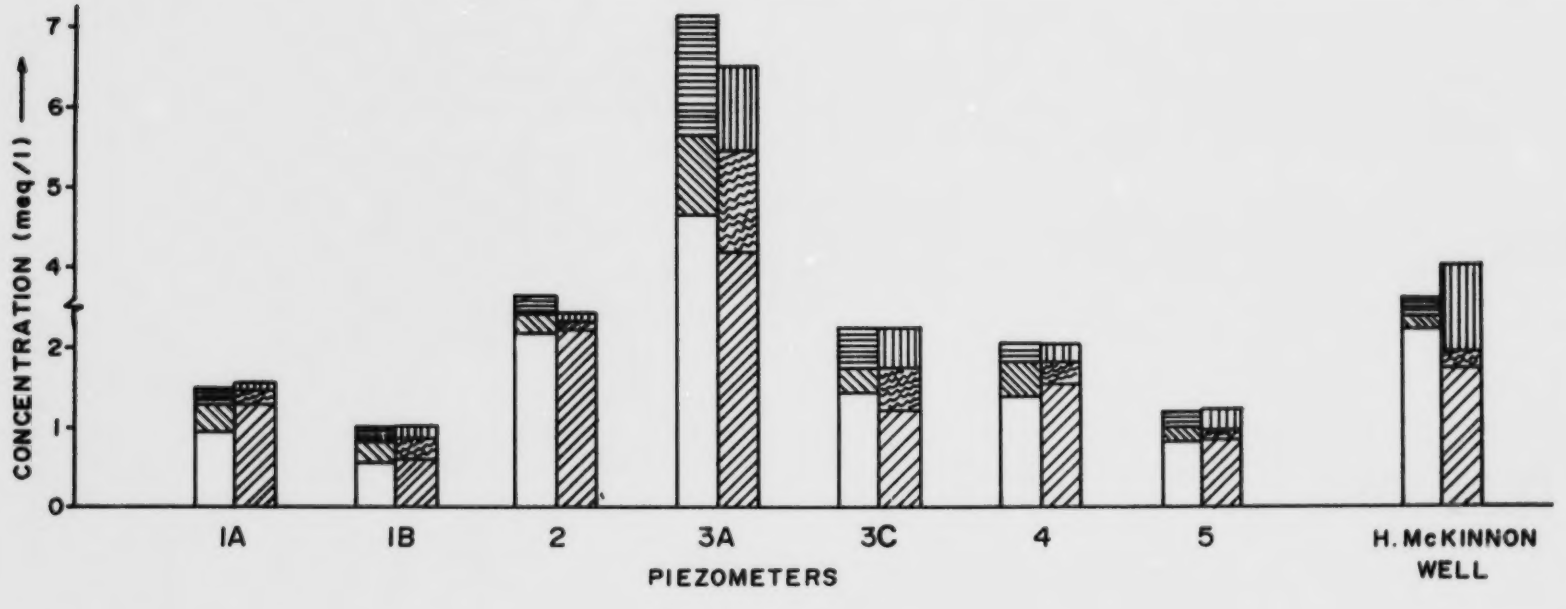
NOLAN, DAVIS & ASSOCIATES

MAJOR ION CHEMISTRY

date: MARCH 1986

project: H84193

FIGURE 10



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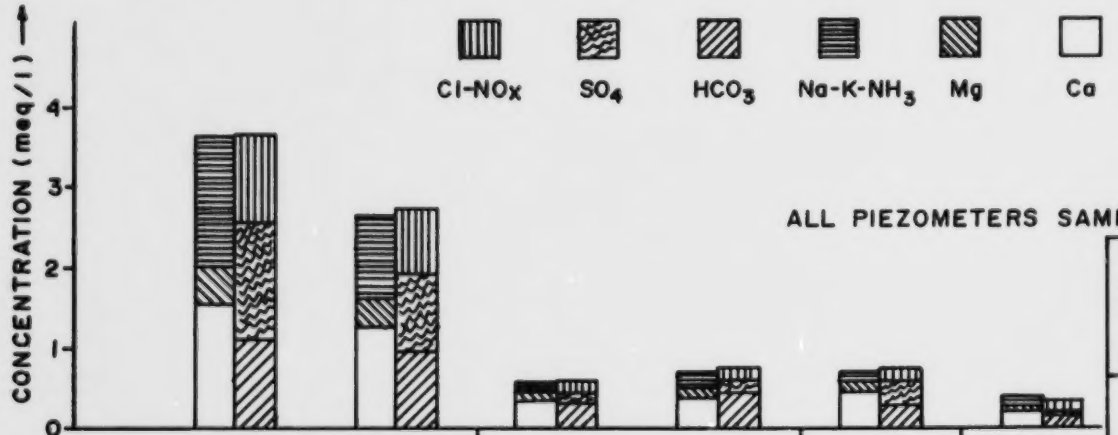

ALL PIEZOMETERS SAMPLED 24/8/84

NOLAN, DAVIS & ASSOCIATES

MAJOR ION CHEMISTRY

date: MARCH 1986

project: H84193

FIGURE 11

PCB WASTE SITE CLEAN-UP

By

Bill Goodings, P. Eng., Head of Waste Management Services

and

David Schram, M.C.I.P., Senior Waste Management Planner

THE PROCTOR & REDFERN GROUP

BACKGROUND

In Ontario, there is not an approved technology to manage and destroy PCB wastes and contaminated equipment or soil. As a result, these types of wastes are stored at public and private locations across Ontario awaiting treatment.

In the Township of West Lincoln (population 9,200), located in the Niagara Region, east of Hamilton, a private company established a PCB waste transfer site in 1979. Over the next 5 to 6 years, approximately 40,000 gallons of PCB liquid waste, many transformer carcasses and other PCB contaminated equipment was received. By 1985 there were over 2,200 pieces of PCB contaminated equipment and several areas of PCB contaminated soil, both on and off the site, resulting from spills and careless handling practices (see Figure 1).

In 1985, the owners declared bankruptcy and for all practical purposes, abandoned the site and the PCB waste. At the time, the site was at capacity, many of the storage containers were leaking and transformers, drums and tankage were exposed to the elements. Since little maintenance had been done, there was potential for further leakage and off-site contamination.

After the closing of the PCB transfer facility, the Ontario Ministry of the Environment (MOE) assumed some responsibility and provided financial assistance for maintenance and security, About this time, PCBs were

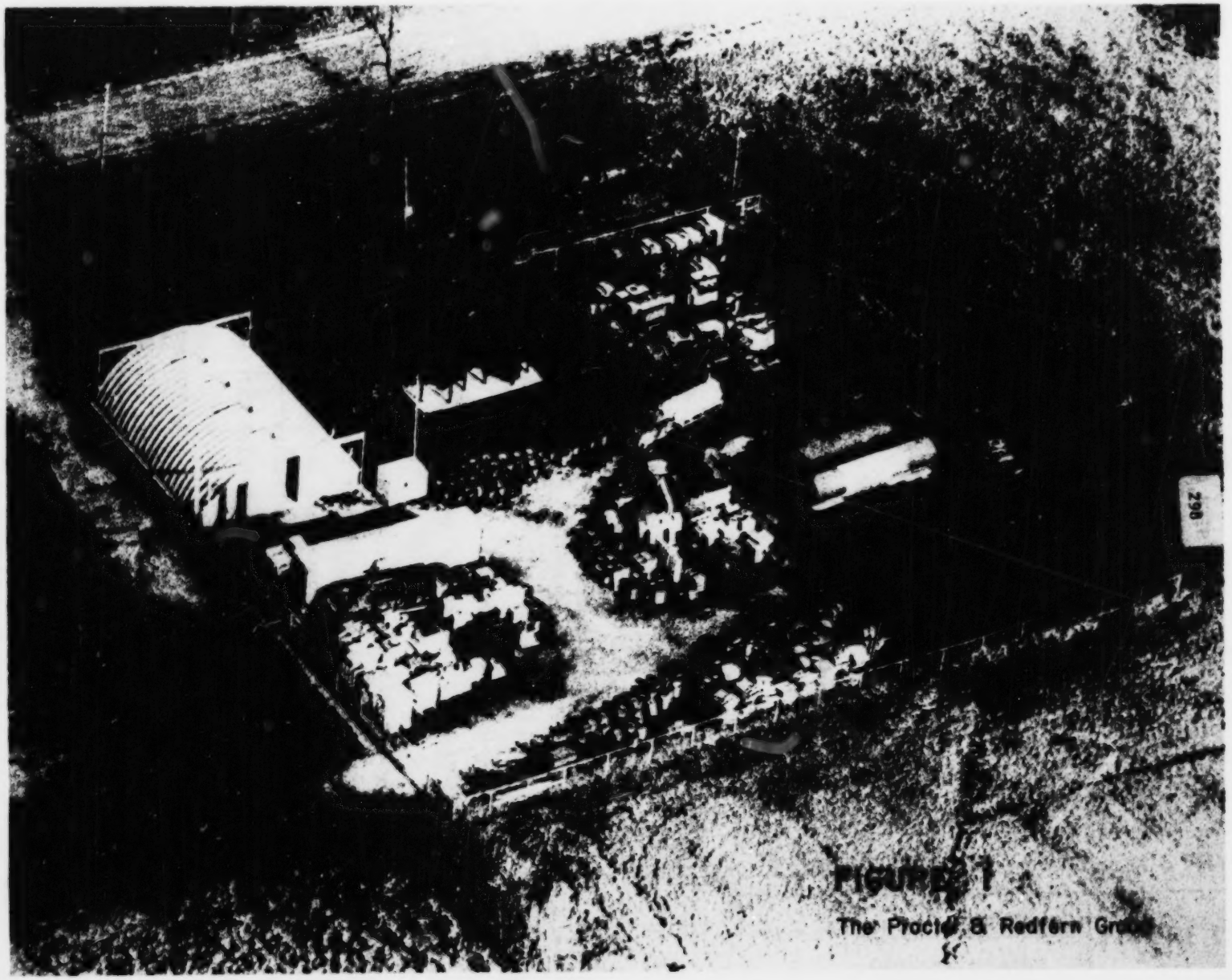

FIGURE 1

The Precinct, Redfern Green

detected in a stormwater catchment lagoon. It was determined that this should be drained and properly stored. Unexpectedly, 92,000 litres of highly contaminated PCB sludge and soil were found in the fall of 1985 by the Ministry's clean-up contractor (Sanexen) at the bottom of the lagoon. The PCB contaminated sludge and stormwater collected were transferred to plastic-lined steel drums and stored at the site.

The Township, local environmental groups, and citizens demanded that the site be cleaned and rehabilitated. Public concern was expressed about the possibility of contaminating the Township's water supply. Its reservoir is located with 3/4 kilometres of the site.

In response to the deteriorating conditions at the site, its potential to incur further environmental damage, and public concern, MOE assumed full control of the site and its management. MOE retained Proctor & Redfern to effect the site clean-up, and construct a secure storage building until an approved treatment/destruction approach became available. At that time, several questions required consideration:

- what was the extent of PCB contamination/migration both on and off the site?
- was there a potential for impact to the Township's water supply?
- what was the quantity of PCB waste requiring storage and management?
- could non-PCB wastes be taken off-site for management?
- what was the extent of PCB contaminated soil?
- how long would storage be required?

- what are the limits when material/soil is considered PCB contaminated?

- is a permanent building that could be used for other purposes preferable to a temporary structure?

- what steps could be taken to reduce the quantity of wastes and contaminated equipment requiring storage?

This paper discusses these issues and the approach taken to site clean-up and rehabilitation.

WHAT ARE PCBs[1]

Polychlorinated biphenyls (PCBs) are synthetic chemical compounds consisting of chlorine, carbon and hydrogen. PCBs were first produced in 1881 and manufactured for a variety of industrial and commercial uses in 1929. PCBs are also known by various brand names which include Aroclor, Hyvol, Pyranol and Inerteen.

Although PCB mixtures are usually light coloured liquids that feel like thick, oily molasses, some PCB compounds form sticky, yellow liquids or a brittle gum ranging in colour from amber to black. PCBs are almost insoluble in water and being denser than water, sink to the bottom when added to it.

PCBs are fire-resistant, do not conduct electricity and are very stable, meaning that they are highly resistant to chemical attack or degradation

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1. The following discussion of PCBs, their use and effects, is taken from a pamphlet prepared by the Canadian Council of Resource and Environmental Ministers entitled, Controlling PCBs - the Nature of the Problem'.

by natural processes in the environment. Although most PCBs are not volatile at temperatures below 40°C, overheating of electrical equipment containing PCBs can produce emissions of acrid, irritating vapours.

HOW HAVE PCBs BEEN USED?[2]

PCB mixtures have had a variety of uses over the years. The major use has been as a dielectric fluid coolant and insulator for electrical capacitors and transformers. PCBs have also been used as hydraulic and heat transfer fluids. Until the early 1970s, PCBs were also used in some electrical appliances; as surface coating for carbonless copy paper, washable wall coverings, upholstery fabrics; as plasticizers in sealants, caulkings, synthetic resins, rubbers, paint pigments, waxes and asphalts; and as flame retardants in lubricating oils.

PCBs may be present in electrical transformers designed to use PCBs as a dielectric fluid, at levels of 40 to 70 percent (i.e. 400,000 to 700,000 parts per million) and at levels of only a few parts per million in some mineral oil transformer units.

Approximately 635 million kilograms of PCBs were produced in North America before their manufacture was banned in 1977. Canada imported approximately 40 million kilograms of PCBs. Widespread PCB contamination of the environment was recognized in the last half of the 1960s by scientists searching for traces of another chlorinated hydrocarbon, DDT. By 1972, researchers and scientists had established that there was sufficient evidence to clearly indicate that the release of PCBs into the environment posed a potential hazard to the environment and human health.

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2. Controlling PCBs - The Nature of the Problem

ENVIRONMENTAL AND HEALTH EFFECTS[3]

PCBs are an excellent example of chemicals that, subsequent to their introduction and commercial use, have been found to exhibit undesirable characteristics affecting the environment or human health. These undesirable characteristics have necessitated after-the-fact measures to manage and control their use and dispersal in the environment. It is somewhat ironic that some of the properties that made PCBs desirable industrial chemicals were also the cause of their undesirable environmental effects. The resistance of PCBs to natural decomposition has contributed to their widespread presence in the environment. Once in the environment, PCBs can be accumulated by various life forms and the contamination passes up the food chain through freshwater and marine plants, birds, fish and other animals and eventually to man.

Before PCBs were recognized as a problem,. they probably entered the environment largely from the disposal of products such as carbonless copy paper, sealants, paints and waste oils. At the present time, PCBs enter the environment from incomplete incineration, from landfill leachate, from leaks in transformers and hydraulic and heat transfer systems and from accidental causes such as transformer fires and transportation spills. Once PCBs are released into the environment, they can be spread by airborne transport. PCBs have been found in the oceans of the world, in Arctic bears, in rainfall, as well as in human beings throughout the world.

The health effects of PCBs have been studied in animal species and, to a limited extent, observed in human beings. In several animal species, reproductive processes and enzyme and immunity systems are affected. Cancers of the liver were also observed in rats fed diets containing

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3. Controlling PCBs - The Nature of the Problem

large amounts of PCBs. The known toxic effects in humans from ingestion, inhalation or absorption of PCBs include chloracne, eye discharges, headaches, vomiting, fever and visual disturbances. But no conclusive direct relationship between cancer and human exposure has ever been made.

THE SITE CLEAN-UP

REGULATORY INITIATIVES

Proposed clean-up activities (i.e. the undertaking) at the site were subject to the requirements of the Environmental Assessment (EA) Act. This Act requires that all reasonable alternatives to an undertaking be evaluated. Since EA is a lengthy process, and an immediate site clean-up was required, an Exemption Order was developed in consultation with the Township and local citizen groups. This process involved a fair degree of mediation with all participants and resulted in the Ontario Cabinet approving the exemption request. Other Ontario legislation, in particular, the Environmental Protection Act and the PCB Regulation (11/82) were followed in the site clean-up.

SIX MAIN PARTICIPANTS IN THE CLEAN-UP

The main participants directly involved in the PCB site clean-up are as follows:

- The Council of the Township of West Lincoln and many interested citizens from the Community,

- The Ontario Government represented through the Ministry of the Environment (MOE),

- A Technical Liaison Committee representing the local citizens, the Township, MOE and Proctor & Redfern,

- The Proctor & Redfern Group (P&R) as Consultants and Project Managers responsible for the design of storage facilities, clean-up procedure, storage of contaminants, and disposal of decontaminated materials,

- Gartner Lee and Associates Limited, Consulting Hydrogeologists,

- Sanaxen, a clean-up contracting firm with experience in hazardous waste site clean-up and emergency response.

PUBLIC CONSULTATION - IT DOES WORK!

At least it is working in the Smithville PCB site clean-up. The public has been actively involved in all regulatory and technical aspects of the site clean-up. At the beginning of the project, a Technical Liaison Committee was established. It includes interested citizens, representatives from area environmental groups, the Township and MOE. This Committee reviewed proposals to clean up the site and provided an excellent forum for consensus decision making.

An important part of the public consultation program was the organization of public open houses and meetings. These events were held to present study findings and discuss alternatives to site clean-up. They proved to be lively debates and very informative to the project team. Certain decisions resulting from the public consultation program were:

- o no PCB wastes would be transported off the site on public roads. To meet this requirements, it is proposed to utilize mobile PCB destruction facilities on-site,

- o a secure building is preferred to the consolidation and temporary storage of wastes. A secure, but temporary, building was designed that could be dismantled following total site clean-up with a minimum of decontamination required,

- o site security, including posting of a security guard and intruder alarm system, is necessary. Security was placed on the site and a site access protocol was established,

- o all non-PCB wastes should be removed for proper treatment. A detailed site inventory identified some 72 drums of non-PCB liquid waste. These drums were removed to an approved and licenced waste treatment facility.

UNIQUE OPEN HOUSE HELD....

Most often, public meetings are held to present solutions to the public which are highly technical and often controversial. As part of the PCB clean-up, MOE supported a different, and we feel, unique approach to public consultation. We held a public open house on the premise that a better informed public could assist in determining a consensus on the clean-up approach.

Rather than developing exhibit after exhibit of treatment processes, site plans and conceptual alternatives, a 'hands-on' information session was held. It was the intent of the open house to provide information about:

- What are PCBs? ... How do they react in the environment? ... and How should they be properly managed?

- What does a clean-up involve? ... What equipment is used? ... and What technologies are available?

- How is public health and safety insured? ... What are the risks? ... What is being done to protect your property?

At the open house, information fact sheets on PCBs were available and background on the site was described. Of more interest to the participants however, were exhibits such as: the site contractor's clean-up suit; PCB secure drum and packing; physical models of the clean-up process; a facsimile jar of PCBs; and other visual examples.

The open house was well attended and judging by the comments received at the session and following, was worth the effort.

WASTE INVENTORY

A physical and chemical inventory of wastes was undertaken by MOE and further refined by Proctor & Redfern. This inventory is summarized on Table 1.

It was found that approximately 40,000 Imperial Gallons of PCB liquids were stored in upright tanks and that many transformers and capacitors still contained PBCs. Moreover, a quantity of contaminated soils existed that could not be determined. Because of PCB's relative immobility in clay soils, it was decided to excavate only highly contaminated soils. This would significantly reduce storage requirements prior to utilizing portable clean-up equipment. An accurate assessment of soils will be made further in the investigation to effect a total site clean-up.

TABLE 1

SUMMARY OF WASTE INVENTORY

Category		No. of Pieces
Transformers:	Large	81
	Small	114
Capacitors:	Large	3
	Small	46
Other Miscellaneous Equipment:		
	Large	8
	Small	19
Contaminated Wood and Trash		111
Miscellaneous Metal		78
Drums:	PCB Solids	506
	PCB Liquid	12
	PCB Sludge	326
	Recovery	25
	PCB Empty	342
	New	133
	Non-PCB	75
	Clean-up Solids	150
Clean-Up Solvent		150
Upright Storage Tanks		2
Truck Tanks		6
Buildings and Structures		5
TOTAL		**2,200**

In addition to the wastes on-site, a considerable amount of cleaning solvent will become contaminated with PCBs and require management. It was, therefore, imperative to select a cleaning process that would minimize the quantity of extra wastes generated.

HOW CLEAN IS CLEAN?

The hydrogeological investigations determined that soils, both on and off the site, were contaminated with PCBs. Proctor & Redfern, in consultation with other experts in the field, considered National PCB standards to determine:

- what is a PCB waste?
- at what limits is a material PCB contaminated and should be removed?
- what are the maximum concentrations of a 'non-PCB' waste?
- when is surface water and stream sediments contaminated with PCB wastes?

An extensive analytical program was developed for this project that included the use of on and off-site laboratories. Several Ontario laboratories were involved and PCB Standards for Management were developed in consideration to existing standards. Table 2 summarizes the PCB clean-up criteria developed for this project that dictated - how clean is clean.

THE CLEAN-UP PROCESS

To meet the objectives for 'how clean is clean' all barrels and materials were externally cleaned prior to storage. The purpose was to minimize post-decontamination requirements of the storage building. A

TABLE 2

SUMMARY OF CLEAN-UP CRITERIA

Liquids		55 ppm
Soil	no greater than	20 ppm
	with secondary protection if greater than	1 ppm
Air Emissions		
	GLC (1/2 hour average)	450 ng/m^3
	GLC (24 hour average)	150 ng/m^3
	GLC (annual average)	35 ng/m^3
Workspace Air		
	TWAEC	50 ug/m^3
	TLV - TWA	1 mg/m^3
	TLV - STEL	2 mg/m^3
Water		5 ug/L
Equipment and Containers		
	surface residual no greater than	250 ug/m^2

TABLE 2 (Continued)

PCB STANDARDS AND GUIDELINES

	ug/g or mg/l or ppm	ug/l or ppb
Fresh water for protection of marine aquatic life (US EPA)	0.000,001	0.001
Interim drinking water standard (MOE)	0.003	3
Influence to wastewater treatment system (MOE)	0.005	5
Dredged spoils (MOE)	0.05	50
Solubility in Water	Aroclor 1254	0.04
	Aroclor 1242	0.2
Road oiling and land spraying (MOE)	5	5.000
Landfill (MOE)	50	50,000
Designated PCB waste (MOE)	50	50,000

cleaning process was developed which is described on Figure 2 that involved:

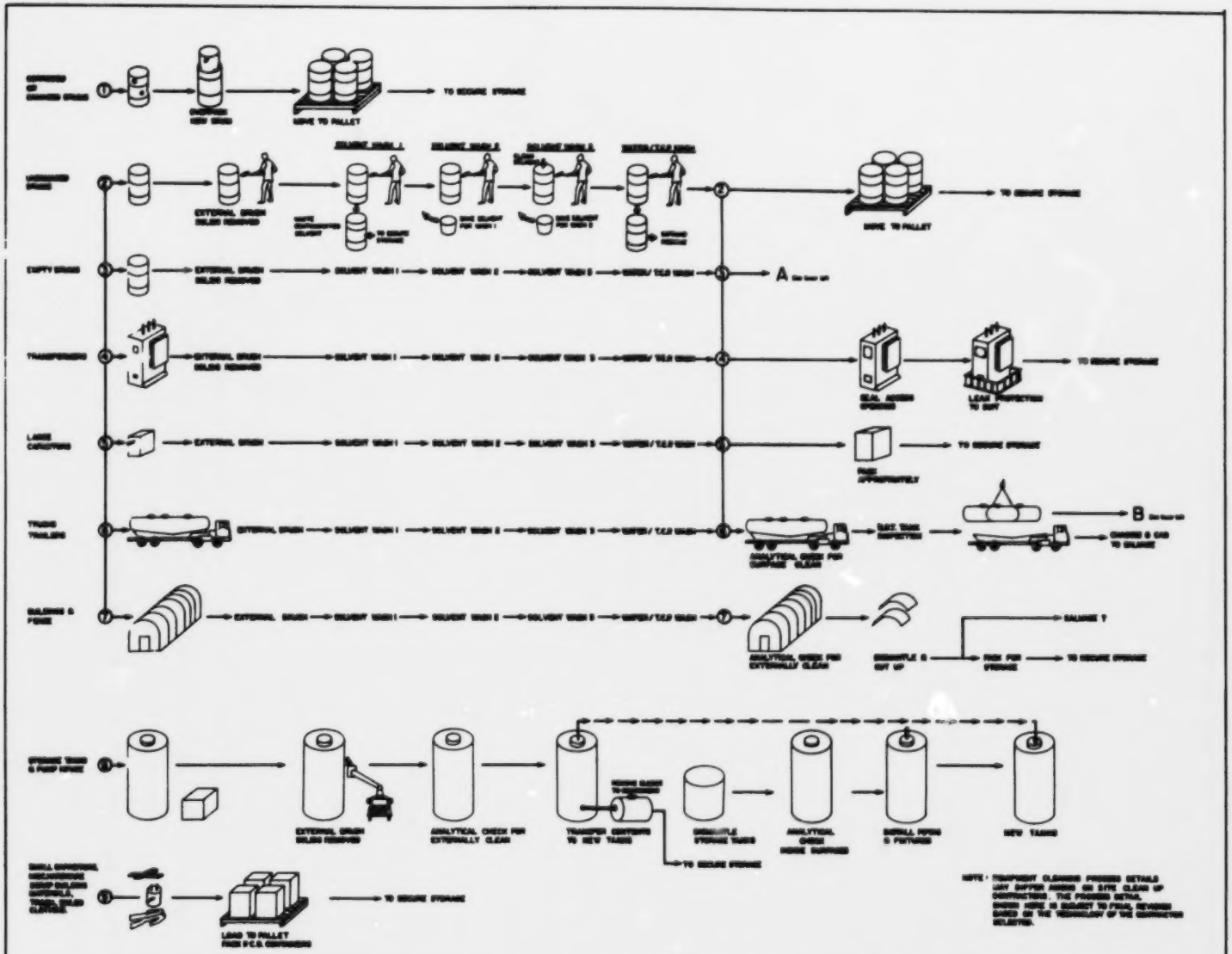
- o construction of large concrete clean-up pads at the site as clean/dirty staging areas,
- o barrels and equipment were progressively cleaned, repaired, repacked and consolidated,
- o a triple rinse process (using solvents and kerosene) was employed followed by a detergent wash to externally clean surfaces prior to storage,
- o all barrels and equipment were then tested (swab test) prior to storage.

All personnel and equipment leaving the site were cleaned using a high powered water wash. A dedicated area for this procedure was also constructed and a trailer provided on-site for emergency and on-going personnel clean-up.

SITE CLEAN-UP CONSIDERATIONS

Prior to initiating detailed site design, several policy considerations were developed to effect the site clean-up. These included:

1. As a general approach, all hardware items and storage drums will be externally cleaned using water and detergents and placed into the temporary secure storage facility. Organic solvent were occasionally used at the discretion of the clean-up contractor for special situations.



PROCESS FLOW SHEET
CONCEPTUAL
CLEANUP AND SECURING OF P.C.B. WASTES
C.W.M.L. SITE, SMITHVILLE, ONTARIO

FIGURE 2

2. Items placed into storage were identified as to category, quantity, and quantity of PCB contained, and an extensive inventory and log developed to assist the eventual destruction and disposal of the PCB materials.

3. Clean-up procedures for material to be removed off-site included a quarantine step in which items were held in isolation while analytical checks were made to confirm the success of the clean-up process.

4. Bare, smooth metal surfaces, including empty drums were be cleaned to an established criteria (250 ug/m^2) and sent to the maximum extent possible to a metal salvage and recovery operation involving furnace disposal, via a designated scrap yard.

5. All soft and porous material was stored in secure containers, pending destruction, rather than attempting any clean-up of PCBs from them.

6. Facilities were provided for decontamination of people, and protective clothing.

7. The extent of soil surface and subsurface contamination was established through field sampling campaigns with analytical determinations of each sample.

8. Contaminated soil were removed and replaced with clean fill.

9. After complete removal of all PCB wastes from the property, a confirmatory survey and analysis will be made to establish complete success of the clean-up campaign.

10. The storage building was placed in a clean area. Prior to selecting the area, soils testing was completed.

11. Placement of the buildings, cleaning/treatment process had consideration for future management requirements. In particular, it is expected a high temperature mobile incinerator will be brought on-site. A site plan was developed to ensure available space for this oepration was provided.

STORM AND SURFACE WATER MANAGEMENT

A primary concern during clean-up was the potential for off-site migration of PCBs. Contaminated water requiring treatment originated primarily from four sources:

- water used for the exterior clean-up of drums, transformers and other equipment,
- water used in shower rooms for personnel clean-up,
- surface runoff water from the site storage compound,
- water used to clean vehicles leaving the site.

To manage and contain surface and clean-up contaminated waters, the following was undertaken:

- a concrete berm was constructed around the site compound to retain surface water and rainfall. No excavations were permitted to avoid creating a 'sinkhole' for PCB migration,
- all water was collected and directed to an on-site wastewater treatment process (carbon filter). Water was sampled and if deemed clean, was released to an adjacent sanitary sewer. Storage capacity equivalent to four days' of generation was provided.

'Grossly' contaminated water was treated initially by an oil/water separator using a coalescing filter. The contaminated filters were secured and are held in storage awaiting ultimate disposal.

Figure 3 is a schematic of the water treatment system used.

MONITORING

An extensive monitoring program was undertaken to determine:

- o the quantity and type of 'non-PCB' wastes stored at the site. Ontario waybill records identified that other wastes were stored and inadequate identification of drums required an extensive sampling process. All non-PCB wastes were repackaged and transported to and approved waste treatment facility,

- o the quality of non-PCB wastes. The concentration of PCB contaminated liquids, soils and other materials was used to determine the management approach. For example:

  - soils with concentrations less than 35 ppb of PCB were not excavated,

  - slightly contaminated metal storage buildings, trucks, and other equipment were cleaned and taken to a scrap yard,

  - high concentrations of PCB wastes or hard to clean transformers, etc. were stored and await treatment.

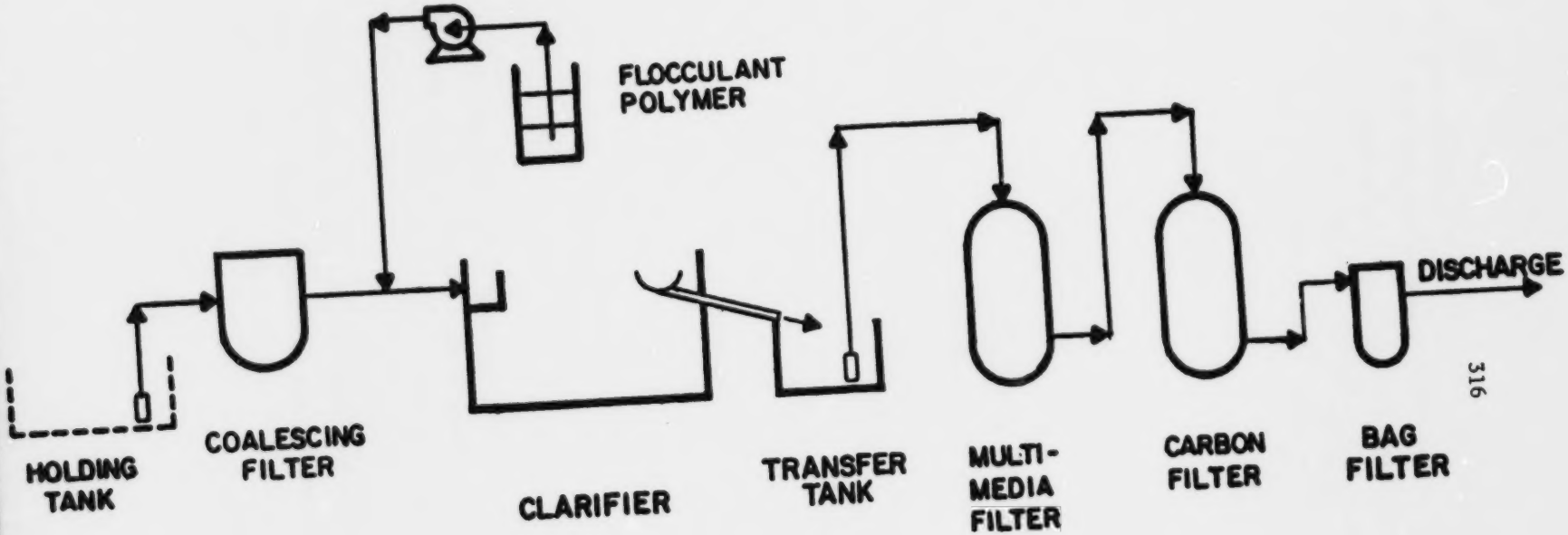


FIGURE 3

WATER TREATMENT SYSTEM

P.C.B. SITE CLEAN UP

The Proctor & Redfern Group

An extensive ground and surface water monitoring program was undertaken to determine the extent of off-site contamination. This monitoring program resulted in identifying a 'plume of off-site influence' and assisted in identifying corrective actions. The ground and surface water monitoring program is being continued.

Other on-site monitoring included: testing for radioactive waste, which proved negative, and monitoring for airborne contaminants.

SITE REHABILITATION

All PCB contaminated soil exceeding 35 ppb will probably be excavated and stored in properly constructed salt domes or other means of safe containment. The site will then be properly graded, ditched and vegetated. It is expected that this site could eventually be sold as an industrial lot.

SECURE STORAGE FACILITIES

The primary objective of our work was to determine the most practical and environmentally acceptable approach to on-site PCB storage. Following an extensive review of alternatives, with the Liaison Committee and the Township, it was decided to construct a temporary storage building with supporting tank farm and soil storage facilities.

The storage building was designed to: minimize post-closure decontamination procedures; provide appropriate temperature and ventilation of drummed waste; and allow for efficient and safe materials handling. Features such as individual spill containment areas, epoxy coated floors, rack storage, large vehicle access doors, and intruder alarm system resulted in a practical and safe containment area for the PCB storage.

It is not known how long the PCB wastes will require storage. However, the current method of storage will allow sufficient time for technically and environmentally capable destruction technologies to be approved in Ontario.

SAFETY AND SITE SECURITY PROGRAM

Prior to any work activity proceeding, a safety and site protocol program was developed. The plan addresses personal safety for all workers and is designed to minimize any potential for contamination. The safety plan was provided to regular users of the sites and the Regional police and local fire departments.

The highlights of the plan are:

- ensuring that all on-site personnel are protected and adequately outfitted before entering the site. Disposable overalls, boots, and gloves are made available and reusable rubber boots, respiratory equipment, safety glasses and hard-hats are provided,

- providing emergency and first aid equipment, such as fire extinguishers, eye wash and personal clean-up stations,

- establishing an access protocol. A security officer located at the site entrance is responsible for recording all site movements including reasons for entry.

- cleaning all road vehicles before leaving the site,

- preparing a contingency plan in the event of accidental spill or gaseous release. This includes an emergency response plan whereby local authorities, neighbours and regional services (i.e. fire and police) would be notified,

- establishing personal hygiene and conduct regulations which are posted on site.

CONCLUSION

On the basis of the recommendations provided by Proctor & Redfern, the decommissioning of the PCB site has been a relatively smooth transition. We expect that the site clean-up and securing of wastes will be completed by the end of the year. Following, we expect to review appropriate incineration technologies and burn wastes on-site.

As engineering consultants, we strongly suggest to municipalities and industries with PCB and other hazardous waste problems, to consult experts early. Our experience suggests that inappropriate remedial action can be more damaging than doing nothing. However, we are also cognizant that there are only so many studies and reports that should be done. In other words - identify the problem - evaluate all reasonable alternatives - and effect the most practical and environmentally suitable solution.

Workplace Decontamination and Temporary Storage of Radioactive Soils at a Small Industrial Site

by

J.W. Barnard*, D.J. Cameron[x] and R.G. Charlewood[+]

ABSTRACT

The operation of a small niobium smelter during the early seventies resulted in contamination of an industrial property in Surrey, British Columbia with low-level radioactive waste. In the summer of 1985, the Low-Level Radioactive Waste Management Office of Atomic Energy of Canada Limited decontaminated the work areas of the site by excavating contaminated soils from under and around buildings. Excavated soils were placed in temporary containment, on site, to await final disposal.

The project required considerable preplanning in the design stages to minimize the environmental impact of the work and to ensure the radiological safety of the public and workers. An environmental screening document was prepared to verify that all the necessary ameliorating measures had been incorporated and to demonstrate the soundness of the procedures being used.

Monitoring during the project showed that no contamination was spread from the site during the operation, that workers on the project received no measurable internal dose, and that the maximum external dose to a worker, attributable to the project, was 0.1 mSv. Monitoring of decontaminated areas following completion of the project demonstrated that, for all but one small spot where further excavation would have jeopardized a building structure, background was reduced to less than 10 $\mu R \cdot h^{-1}$ at 1 metre above finished surfaces. This is the normal background levels for the Surrey area.

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1. INTRODUCTION

In the summer of 1985, the Low-Level Radioactive Waste Management Office (LLRWMO) of Atomic Energy of Canada Limited (AECL), acting on behalf of the Federal Government, initiated a project to decontaminate an industrial site in Surrey, British Columbia. This required excavating radioactive slag from under and around buildings and work areas and isolating it inside a containment structure in one corner of the property. The contaminated soil and slag are to remain in this temporary storage structure until details for its disposal are worked out by the Federal and Provincial Governments.

2. BACKGROUND

2.1 History of the Site

The slag was produced by a small smelter that extracted niobium from imported ore during the early 1970s. By the mid-1970s, the company had ceased operations and the property had been purchased by the present owner, who was unaware of the nature of the waste on the site. The slag was used as backfill during site improvements and, as a result, was mixed with about 2000 m^3 of clean river sand. It was deposited under pavements, foundations and concrete floors, resulting in higher than normal background radiation in parts of the work area.

In 1984, the Federal Government accepted responsibility for disposal of the waste in co-operation with the Province of British Columbia. Since that time, the LLRWMO has carried out two studies: one to characterize the chemical properties of the waste (WNRE, 1985) and one to delineate and quantify the extent of contamination on the site (Klohn Leonoff, 1984).

In 1985, the LLRWMO reached agreement with the present owner to build a temporary storage and containment structure for the wastes, decontaminate the work areas of the site, isolate the wastes inside the containment, and restore the work areas.

2.2 Chemistry of the Slag

The slag was the waste product left over when niobium metal was extracted from ore by the thermite process.

Chemical analysis of the slag was carried out at the Whiteshell Nuclear Research Establishment (WNRE), Geological Services Canada (GSC) and the University of Manitoba, Department of Earth Sciences (WNRE, 1985). Table 1 gives a summary of the results and also lists the major components and their forms in the slag. The analysis accounts for 95% by weight of the slag. Aluminum, the reducing agent in the thermite process, is the dominant element in the slag.

The predominant radioisotopes present are shown in Table 2. Radon and thoron emanate from the slag and their daughters are also present.

Examination of the slag by X-ray diffraction and thin-section petrography showed that the slag is highly crystalline. A beta-alumina-type structure predominates. A peroskovite phase is also present.

Static and flow leach tests using 3% NaCl solutions and deionized water indicated that aluminum and barium are the principal leachable constituents of the slag. Kluckner and Krueger-Scheel (1984) who studied the leaching characteristics of the slag at various pH values, also identified aluminium

TABLE 1

ANALYSIS OF THE SURREY RADIOACTIVE SLAG*

Element/Substance	Concentration (Wt.%)
Al (as Al_2O_3)	48.6
Ba (as BaO)	9.07
Si (as SiO_2)	6.5
Ca (as CaO)	5.92
Na (as Na_2O)	3.8
Ti (as TiO_2)	3.12
Ce (as CeO_2)	2.67
Nb (as Nb_2O_5)	3.0
Fe (as Fe_2O_3)	2.5
Th (as ThO_2)	1.13
Mg (as MgO)	0.50
Zr (as ZrO_2)	0.50
Nd (as Nd_2O_3)	0.30
K (as K_2O)	0.26
Mn (as MnO_2)	0.12
Sr	0.096
U	0.031
P	0.01
As	0.0074
Ni	0.008
Y	0.0017
Zn	0.001
Se	Suspected
La, Cu	<0.01
Cs	<0.003
Rb,Pb,M_o,Br,Cr	<0.001
Carbonate C (as CO_2)	2.0
Elemental C	0.1
S (as SO_3)	0.115
Chemically Bound Water (H_2O^+)	3.7
Loss on drying (H_2O^-)	1.2

* Taken from most reliable results in Table 5(a) of WNRE (1985).

TABLE 2

CONCENTRATION RANGE OF PRINCIPAL RADIOISOTOPES IN THE SURREY RADIOACTIVE SLAG*

Radioisotopes	Concentration ($Bq \cdot g^{-1}$)
^{238}U	4.3 - 7.4
^{234}U	4.5 - 7.1
^{230}Th	4 - 11
$^{226}Ra(^{+})$ (by Alpha Spectrometry of crushed and sieved samples)	2.5 - 4.4
(by Gamma Spectrometry of crushed and homogenized samples)	5 - 23
^{232}Th	27 - 79

* Taken from Tables 6 and 7 of WNRE (1985)
($^{+}$) Difference in ranges of values for the two methods is explained, in part, by inhomogeniety of the slag.

and barium as the principal leachable species. Radium was the predominant radioactive species in the leachate. Variations in the leach rates with time amongst the various elements indicates that the slag does not dissolve congruently.

For the remedial work planned for the summer of 1985, barium and radium were thought to be the leachable components of greatest environmental concern. Data from groundwater analysis at the site and more recent detailed groundwater chemistry modeling by Beak Consultants (Beak, 1986) tend to confirm this view.

2.3 Delineation of the Waste

Figure 1 is a plan of the site. Much of the site is paved. A storm drain system carries rainwater to a drainage ditch along the neighbouring railway right-of-way.

During the spring of 1984, 20 test pits and 3 augered test holes were sunk on the site. Soil samples were taken from various depths in the holes. A gamma survey of the entire site on a 5-m grid was also made at this time.

On the basis of the soil sampling data and the gamma survey, approximate contours of contaminated zones were established. These are shown in Figure 1. The levels of contamination are stated in terms of ppm** thorium, the predominant radionuclide in the slag. It was estimated from this study that 3900 m^3 of soil would have to be moved in order to clean up the whole site. Of this, 3200 m^3 would be contaminated.

The site is underlain by a dense sandy silt. The backfill was added to the site to depths of up to 3 m, in most instances without removal of the surface organic layers.

The three augered test holes and seven of the test pits were backfilled with a series of shallow and deep piezometers. The deep piezometers penetrated the dense silt. Piezometer studies indicated that hydraulic gradients were directed downward into the silt and to the northeast into site drains and the drainage ditch but, because of the highly impermeable nature of the silt, most of the shallow subsurface flow was toward the northeast.

** 1 ppm = 1 $\mu g \cdot g^{-1}$

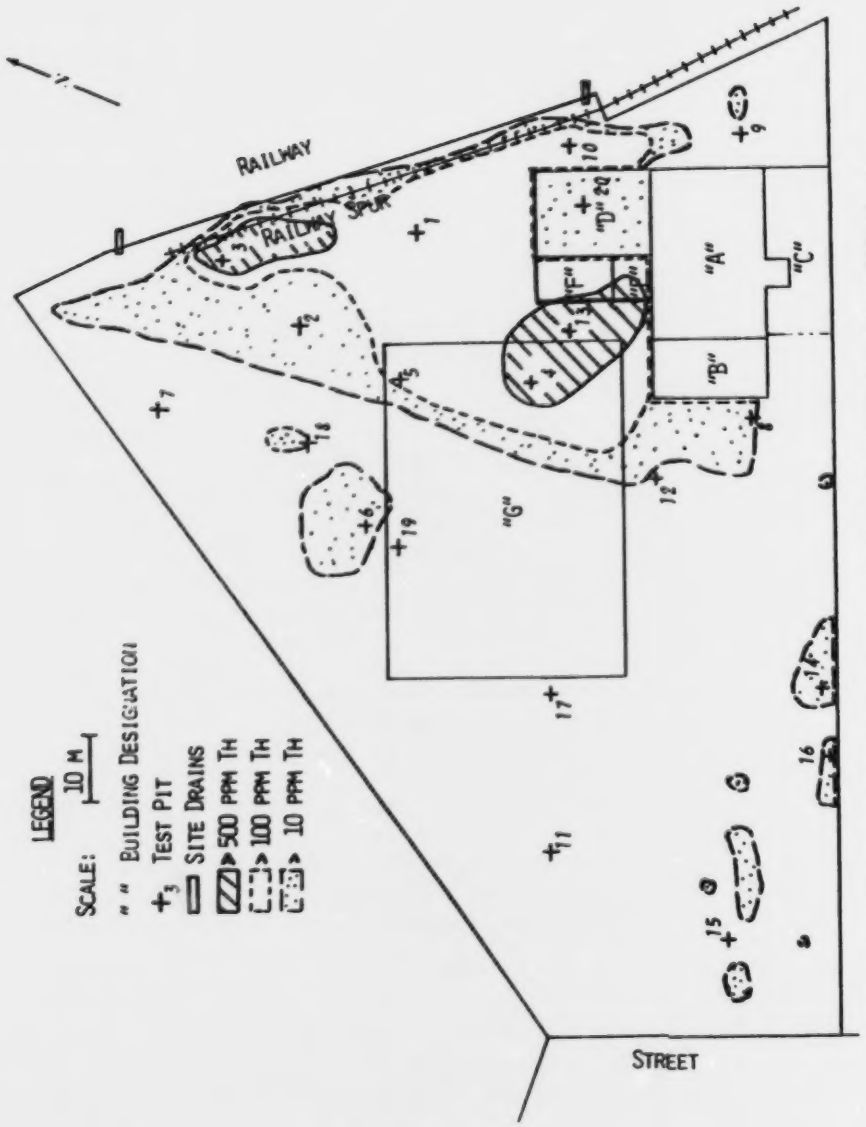

FIGURE 1: ESTIMATED THORIUM CONCENTRATIONS IN SOIL, INDUSTRIAL SITE, SURREY B. C.

TABLE 3

DISSOLVED RADIONUCLIDES IN WATER SAMPLES*

	U ($\mu g \cdot h^{-1}$)	Th ($\mu g \cdot h^{-1}$)	Ra ($Bq \cdot L^{-1}$)
Site drain 1	0.20	5	0.02
Site drain 2	0.10	4	0.01
Test pit 3	0.50	7	0.50
Test pit 9	0.10	23	0.02
Test pit 10	0.10	6	0.10
Test pit 11	0.40	3	0.02
Test pit 15	0.10	2	0.02
Test pit 20	0.40	12	0.01
Canadian Drinking Water Guidelines and BCMOE Polution Control Objectives	20.0	-	1.0

* From Klohn Leonoff (1984)

During these studies, water samples were taken from test pits and site drains. These were analyzed for uranium, thorium and radium. The concentrations measured are shown in Table 3 as well as the Canadian Drinking Water Guidelines (Health and Welfare, 1978) and the B.C. Ministry of the Environment's (BCMOE) industrial effluent standards (BCMOE, 1975). Although no pollution control standard has been established for thorium, the philosophy used by Health and Welfare Canada to establish guidelines for other radionuclides implies a limit of 100 $\mu g \cdot L^{-1}$ for thorium in drinking water. Although none of the radionuclide concentrations exceed the standards, radium concentrations in samples from the two lowest test pits, where the slag was saturated with groundwater, are close to the maximum concentrations recommended by the standards.

More recently, samples taken from the piezometers were analyzed for barium. Barium concentrations in the lower lying shallow piezometers were determined to be as high as 3200 $\mu g \cdot L^{-1}$, which exceeds the drinking water standard of 1000 $\mu g \cdot L^{-1}$. This confirms the results of the laboratory leach tests that barium and radium were the elements of water quality concern.

2.4 Project Objectives

The LLRWMO's objective was to decontaminate, as thoroughly as possible, as much of the site as the limited space for containment would permit. At a minimum, the areas indicated in Figure 2 for excavation were to be decontaminated.

The agreement with the owner specified that no remedial work would be required that would jeopardize the structural integrity of buildings, that decontamination would be carried out with due regard to sound health physics practice, and that the site would be restored using a quality of construction as good or better than that which existed prior to commencement of remedial work.

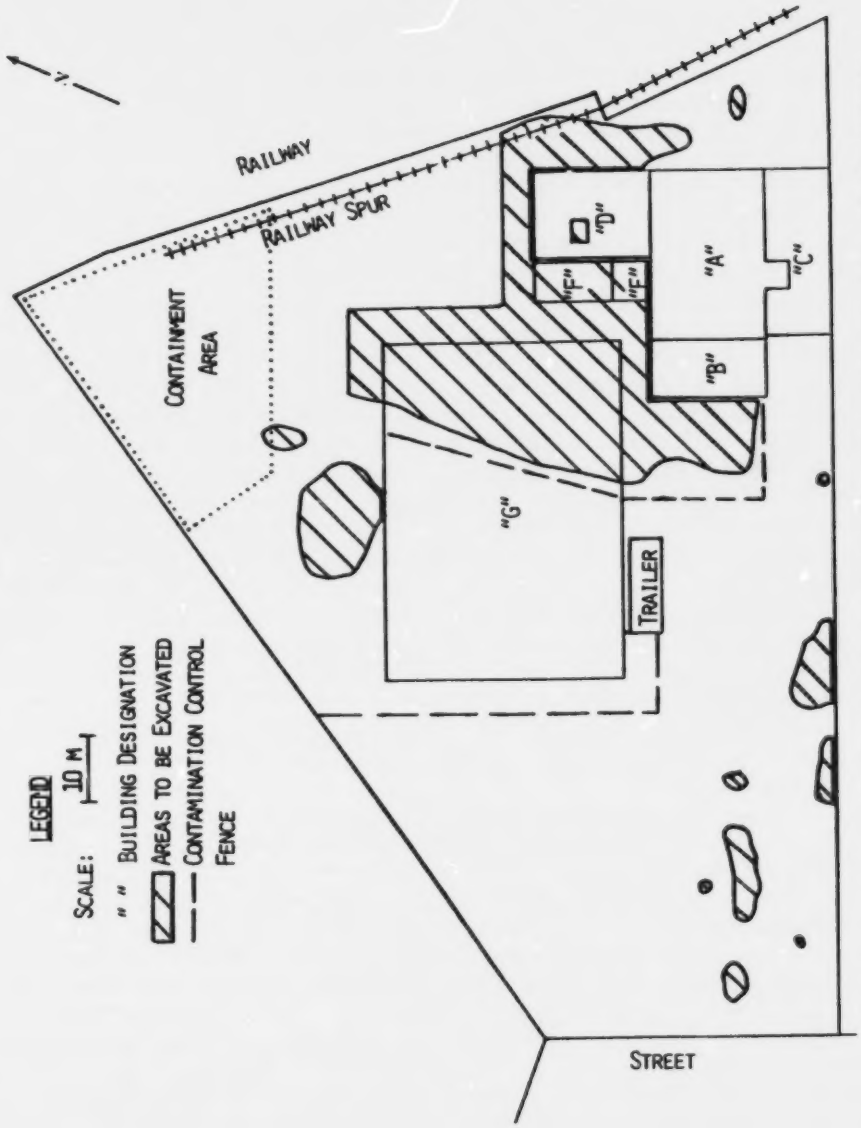

FIGURE 2: AREAS TO BE EXCAVATED UNDER THE AGREEMENT BETWEEN THE SITE OWNER AND THE FEDERAL GOVERNMENT

The sole radiological standard determining an adequate level of decontamination was the specification that radiation fields would be 10 $\mu R \cdot h^{-1}$ or less at 1 m above finished surfaces and 20 $\mu R \cdot h^{-1}$ or less at 1 m above the containment.

3. PLANNING

3.1 Environmental Screening Document

An environmental screening document (ESD) was prepared to assess the impact, if any, the project might have on the environment (Barnard, 1985). This proved to be a useful planning aid. The screening procedure outlined in the Screening Guide (FEARO, 1978) was followed. This served as a handy checklist of environmental concerns to consider in advance and enabled us to preplan mitigating measures into the operation that would limit health risk to workers and the public and protect the environment.

In preparing the screening document, particular emphasis was placed on radiological hazard. It was estimated that the maximum individual inhalation dose to workers from airborne particulate in the absence of any protective measures would be 0.2 mSv for completion of the project. The maximum radon dose would be 0.3 mSv and the maximum external dose would be 0.3 mSv. Therefore, the maximum total dose possible for the project (internal plus external), in the absence of any mitigating measures, was estimated to be 0.8 mSv. The annual regulatory dose to members of the public is 5 $mSv \cdot a^{-1}$.

During preparation of the screening document, two containment designs were evaluated: an above-ground concept and a below-ground concept. It could not be demonstrated that the proposed underground containment would adequately restrict the exposure of the slag to groundwater. Because of this and in view of the leachability of barium and radium, underground storage of the waste was judged to have greater potential for impact. Therefore, the above-ground design was adopted.

The possibility that pumping water out of the excavation would lead to the discharge of radium- and barium-contaminated water off site was investigated. An analysis showed that, even if water were discharged that contained these elements in concentrations greater than the industrial effluent standards, dilution in the storm or sanitary sewers would quickly reduce the concentrations to insignificant levels and no threat to health or environment would result.

Nevertheless, preparations were made to monitor radium-in-water on site and barium-in-water at a nearby commercial laboratory. Radium could be monitored overnight, but 12 hours were required to monitor for barium, delays that would slow down construction during rainy periods. Tentative plans were made to store and/or decontaminate water prior to discharge.

Other mitigating measures for the project are listed in Appendix I of the Screening Document (Barnard, 1985). These included wetting down the piles of contaminated soil to prevent dusting, maintenance of site drainage during construction, provision for decontamination of men and equipment and contamination control.

Radiation monitoring, at least at the outset, by constant air sampling, for airborne contaminants in particulate form was recommended. Also, monitoring of workers, by thermoluminescent dosimeters (TLDs) for external dose and by urinalysis for internal dose, was recommended.

3.2 Containment Design

The waste containment facility was constructed of three rows of interlocking concrete blocks placed on a 150-mm asphalt surface. The layout of the facility was planned to conform to the north corner of the property as shown in Figure 3.

It was designed so that the waste could be packed into the enclosure from east to west to the level of the top of the second row of blocks and mounded in the middle to provide a 1 in 10 drainage slope to the outside edge. The position of the western wall of the facility was dependent on the final volume of waste enclosed.

The waste was to be covered with 100 mm of sand and a high-density polyethylene liner (HDPE). A special testing program was required to insure the quality of the HDPE joints. The HDPE was to extend out between the two top rows of blocks as shown in the detailed sketch in Figure 3. It was planned so that the top row of blocks would be added and 350 mm of aggregate would be compacted on top for protection. The top row of blocks was designed with spaces between blocks to permit drainage.

3.3 Public Relations

A construction permit was obtained from the Surrey Municipality. The Environmental Screening Document was used as supporting documentation for permit application. The municipality requested that the LLRWMO's engineers visit the neighbours on either side of the site to explain the project and discuss any of their concerns. The main concern of the next-door neighbours was that the boundary of their properties may have been contaminated by spillover during backfilling in the early seventies. They requested that stray contaminants (expected to be in the form of chunks or boulder-sized pieces) be picked up and placed in the new storage. This was agreed to. The neighbours viewed the project as a positive improvement. The permit was granted.

A press release was issued to the Vancouver area media. Reporters and correspondents from both print and electronic media were invited to vist the site during the construction phase.

3.4 Instruction

A safety and education meeting was held with construction personnel and others concerned with the operation on the day before excavation began. The material being handled was described and the estimates of dose to workers calculated in the ESD were presented. No attempt was made to explain these doses in terms of risk. Rather, the doses were compared to understandable everyday doses such as one chest X-ray, working as an airline stewardess or pilot, or moving to Denver for a year.

The use of a Geiger counter was demonstrated, and the workers were given a chance to use it. The proper way of removing potentially contaminated protective clothing was demonstrated and instruction in personal contamination monitoring was given at this time.

The men were issued with TLDs and informed that urinalysis would be required for internal dose monitoring. They were given time to ask questions.

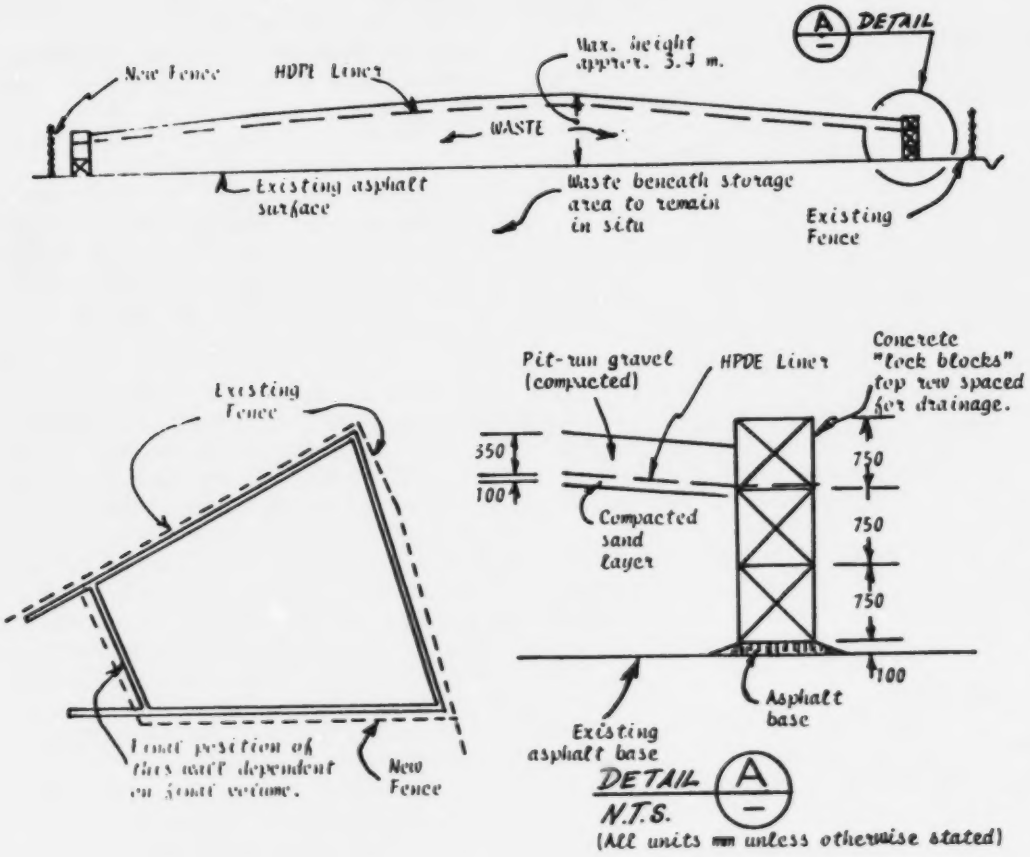

FIGURE 3: PLAN SKETCH AND SECTION OF WASTE CONTAINMENT, SURREY B. C.

4. CONSTRUCTION

4.1 Mobilization and Containment Construction

Construction began with installation of site services needed to support the operation. A construction trailer was moved onto the site and sewer, water and electricity were installed. This provided space for a radiological health office and washup facilities for decontamination of men. As well, a cable-testing frame was removed from building G to make way for excavation there.

The contamination control area was cordoned off at this time. This area is outlined in Figure 2 and initially surrounded all the contaminated areas identified in Figure 1 except for the small outlying patches near the west (street side) of the property.

The northwest, northeast and south walls of the containment facility were built up to the second row of blocks. The west side was left open so that trucks could back in and dump the waste.

4.2 Excavation

The small outlying patches of contaminated soil on the west side of the property were excavated first. These were mostly surficial pockets of slag spilled from drums. Once these were cleaned up and placed in the containment, excavation was started inside the contamination control area.

The contaminated regions were identified with portable scintillometers and Geiger counters. Contaminated soils were removed until normal background levels were achieved. As expected, the contours of contaminated soil plotted in Figure 1 were only approximate. Wider areas had to be excavated, particularly in the southeast corner of the property and inside building G, as shown in Figure 4. However, the average depth of contamination was not as great as expected; consequently, the volumes requiring removal were not as large as predicted. This permitted all the material between the railway spur and building G and north of building D to be excavated, even though this was not required under the terms of the agreement with the owner. This area was excavated to within 1 m of the south wall of the containment structure.

Part of the railway spur was removed to make way for the containment structure. After the contamination to the west of the spur had been removed and three or four loose pieces of slag had been removed from the surface, all radiation fields measured both on contact with the ground and at 1 m above the surface of the spur were in the 7 to 9 μR/h range (normal background). Since the spur had been built with clean ballast brought onto the site from elsewhere, there was no justification for excavating it.

Although every effort was expended to remove all contaminated materials from those parts of the site not within the containment enclosure, it was not possible to retrieve all the radioactive slag from underneath building and crane columns in building G without extensive shoring and underpinning. The soil under main building supports was left undisturbed with sufficient slope away from column bases to prevent cave-in or slumping. The amount of contaminated soil left under building G is estimated to be about 22 m^3 or 0.08% of all soil excavated.

Before the beginning of construction, a survey of the property northwest of the fence located two pieces of slag lying on the surface near the

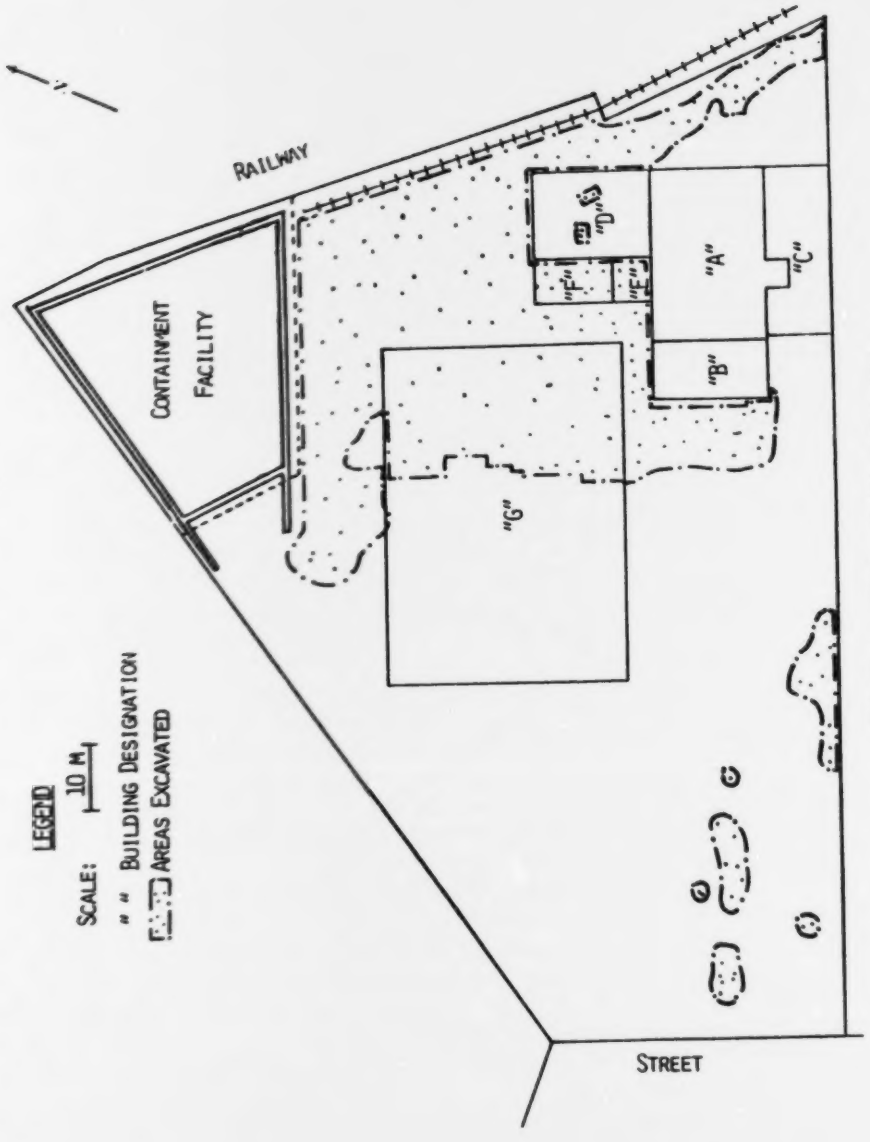

FIGURE 4: AREAS ACTUALLY EXCAVATED

fence. These, as well as slag pieces discovered along the Railway right-of-way by the original 1984 survey, were retrieved and placed in the containment. A brief survey of the property line to the south revealed no radioactive material on that neighbour's property.

The final volume of soil excavated and placed in containment was approximately 2600 m^3.

4.3 Restoration

All areas excavated were backfilled with clean sand and gravel and compacted. The outdoor areas were then paved with asphalt. Areas inside buildings E and F were paved with asphalt. The floor of building G was repaved with 200 mm of concrete. The containment was surrounded by a 2-m-high chain link fence, to prevent access to the top of the structure.

4.4 Radiation Protection

4.4.1 Contamination Control. Tyvek coveralls, rubber boots and cotton gloves were required gear for persons working inside the barrier. Monitoring equipment was provided at the entrance to the control areas and men were required to monitor themselves and remove their protective clothing on leaving this zone. Trucks and equipment were also monitored when passing out of the area.

Contamination control measures were maintained to the end of the excavation work, although there was no indication that this contaminated material would spread by tracking on shoes or tire treads. However, it was evident that lumps of the material could be conveyed off site, wedged between dual wheels. Therefore, besides radiation monitoring, the gaps between dual truck tires were inspected visually before trucks departed.

Dust levels were controlled during hot, dry periods by wetting excavated materials with a water spray. Contaminated soil placed in the containment was packed daily and covered at night to protect it from both wind and rain. An effort was made at the beginning of the project to monitor nuisance dust levels in the air. However, this measurement requires a precision chemical balance. Because no suitable balance could be found near enough to use on a routine basis, measurement of dust levels as a means of estimating airborne radioactivity was abandoned as impractical. All airborne radioactivity measurements were made by counting activity collected on air sample filters.

4.4.2 Air Monitoring. The Environmental Screening Document (Barnard, 1985) for this project recommended that workplace alpha-in-air monitoring be instituted, at least at the outset to determine the concentration of long-lived alpha emitters (radium, thorium and uranium) in the air. This was done using breathing zone samplers and high volume samplers. Breathing zone samplers (Mine Safety Appliance) suffer from a lack of precision in measuring airborne activity at low concentration because of the low sampling rate ($0.8\ L \cdot m^{-1}$). However, they do have the advantage of sampling the air the worker is actually breathing. Unfortunately, they are uncomfortable to wear during periods of strenuous activity and the men did not want to wear them after the third day of excavation. On the fifth, sixth and seventh days, however, the work moved into the alley way between buildings G and B.

The weather was hot and dry. This area was a sheltered space where dust concentrations could build up in the air. This location was also judged to be important for high volume sampling because the air conditioners for the offices were also located in this alley way. The high volume sampler (40 $L \cdot m^{-1}$) was set on top of the air conditioner so that air for both workplaces could be sampled at once.

Short-lived radon and thoron daughters were detected on all air sample filters. Short-lived daughters tend to mask the long-lived radioactive components collected on the filters. The breathing zone filters were kept and counted the following day, after the radon daughters had decayed sufficiently to determine whether or not significant exposure to long-lived radionuclides had occurred. Then they were discarded, even though it was clear that short-lived daughters were still decaying. The high volume samples from August 28 and August 29 were counted five and four days after collection, respectively. These measurements showed that long-lived alpha-in-air concentrations were less than 4×10^{-4} $Bq \cdot m^{-3}$, or at least two orders of magnitude lower than the derived air concentrations (DACs) for thorium and uranium listed in ICRP Publication 30 (ICRP-1979).

Because negligible amounts of long-lived alpha emitters were indicated, monitoring of workplace air was suspended after the first seven days of excavation. Excavation was completed after seven more workdays. Although radon working levels (WL) were not specifically monitored, they were estimated based on the decay characteristics of the daughter radionuclides following collection on the airborne dust sampling filters. Estimates from both high volume and breathing zone samplers indicate that radon daughter levels were approximately 3.0 mWL. This is not much greater than the levels for residential radon in the Vancouver area (McGregor et al., 1980).

In summary, exposures of workers to radon daughters on the site during the project were not significantly different than for any other site in the Vancouver area. No significant intake of long-lived radioactive materials occurred during the project. The latter conclusion is supported by the internal dosimetry results (see Section 4.4.4).

4.4.3 External Dosimetry. Standard AECL identification badges containing thermoluminescent dosimeters (TLDs) were issued to workmen. These were worn by workmen until excavations were completed and the containment sealed. When workmen were away from the site, the badges were left in the Engineering and Health Office located in the construction trailer. The background fields in this office were 7 to 8 μR/h. Spare dosimeters were also kept in this office for the duration of the project. Unused dosimeters were used as controls. Dosimeters were carried to and from Surrey in hand luggage and were not subjected to X-ray inspection. The highest dose recorded (after subtracting the controls) was 0.1 mSv. This is approximately the radiation dose that would be received while flying from Vancouver to Hawaii and return on a commercial airline. It is probably attributable to the work done on the site. It is more than twice the standard deviation on TLD measurements (≈ ±0.04 mSv) and it was registered on the dosimeter of the labourer who worked the most time in proximity to the contaminated soil. He guided the backhoe in the excavations and did the hand excavations. This person was also responsible for packing and covering the containment facility at the end of each day. Personal external dose data were mailed to each individual by the Radiation and Industrial Safety Branch (RIS) at Whiteshell.

4.4.4 Internal Dosimetry. Internal dose was estimated from urinalysis. Urinalysis bottles were issued only to those people who worked in contact with the contaminated soils. This amounted to only 14 men since some workers were assigned to backfilling and resurfacing. Two bioassay samples were taken from each workman - one on the first day worked and one on the final day of potential exposure. Potential exposure ended with closure of the containment or when the workman left the project. Urine samples were assayed for thorium, uranium and radium. Internal dosimetry by urinalysis can detect an intake of 1.0 $Bq \cdot d^{-1}$ of thorium (about 10^{-2} of one annual limit of intake) and 10^{3} $Bq \cdot d^{-1}$ of radium (about 5×10^{-2} of one annual limit of intake). Even smaller daily intakes of uranium can be detected. No thorium or radium was detected in any of the initial or final urine samples. Uranium detected was within the limits for normal dietary intake. All 14 workers received written notice of their bioassay results.

4.5 Environmental Monitoring

Although facilities were available for monitoring radium and barium concentrations in water discharged from the excavation, this was not required. The weather was dry except for two days, and pumping was not required. No contaminants were discharged from the site as liquid effluent.

Since no significant radioactivity was detected in air at the excavations, it is unlikely that radioactivity was carried off the site by the wind.

4.6 Decontamination Standards Achieved

A ground gamma survey of each area was carried out by AECL after the radioactive material was removed, to confirm that the criterion of 10 μR/h at 1 m above ground, established in the agreement between the site owner and the LLRWMO, would be met.

The official post-remedial works (as-built) survey of the site was made by the British Columbia Ministry of Health (BCMOH) Radiation Protection Services (RPS). This official survey is used as the basis for acceptance of the remedial measures of the "as-built" facility. This survey was done with a Reuter-Stokes RSS-111 ionization chamber detector, which measures radiation in $\mu R \cdot h^{-1}$. It is a standardized unit that also responds to all components of background radiation, both terrestrial and cosmic. The dose rates determined by this instrument are a true reflection of the total radiation fields existing on the site. This radiation survey was made on the original grid points established by Klohn Leonoff (1984) for the original site survey. Fields at all points on the grid were found by the BCMOH survey to be less than the "10 $\mu R \cdot h^{-1}$ at 1 m" criterion. Fields at some extra points along the south fence of the containment are slightly elevated, up to 14 $\mu R \cdot h^{-1}$, due to contamination underneath the concrete wall of the containment. One extra point surveyed in the BCMOH survey at the third column base north of the southeast corner of building G has a field of 11.5 $\mu R \cdot h^{-1}$ at 1 m above the floor, caused by material that could not be removed from under column bases.

Both radiation surveys showed that radiation fields on top of the containment facility are less than 20 $\mu R \cdot h^{-1}$ at 1 m above finished surfaces, as required by the site owner - LLRWMO agreement. Natural background radiation fields in the Surrey geographic area are between 6.5 and 10 $\mu R \cdot h^{-1}$. Both the AECL and the official BCMOH surveys show that the radiation fields in

those parts of the site that were decontaminated are not significantly different from these values. Substantially all radioactive slag originally on 7800 Anvil Way and adjacent properties is now confined within or under the containment facility.

5. IMPACTS

No adverse environmental impacts on the site or the surroundings attributable to the project were noted. Air monitoring during construction and internal and external dosimetry for workers indicated that the project produced no significant radiological impacts.

Since radiological impacts on workers were estimated during preparation of the environmental screening document, it is instructive to compare the measured values with those estimated.

Radon daughters were measured on site only twice during the operation. Both times, radon background levels were determined to be 3 milli working levels (mWL). If we assume that this level persisted for the full 1.5 months during mobilization and ignore the fact that at least 50% of this is contributed by normal radon backgrounds, we estimate a maximum exposure of 1.5 x 3 = 4.5 milli Working Level Months (mWLM). If 4.8 WLM corresponds to a whole body dose of 50 mSv (ICRP, 1981), then the maximum individual dose to workers from radon would be 0.05 mSv.

The maximum external dose received by an individual working on the project was 0.1 mSv. No internal dose due to inhalation or ingestion of long-lived alpha emitters (actinides) could be detected either by urinalysis or by workplace monitoring.

Table 3 compares the projected and measured values for worker dose.

TABLE 3

COMPARISON OF PREDICTED AND MEASURED DOSE RECEIVED BY WORKERS DURING DECONTAMINATION AND RESTORATION PROJECT

	Maximum Predicted Dose[1] (mSv)	Measured Dose (mSv)
Internal (Actinides)	0.20	N/D
Radon	0.30	<0.05
External Dose	0.30	0.10
TOTAL	0.80	<0.15

[1] (Barnard, 1985)
N/D Not detected

Some positive impacts of the project are that radiation fields in the work place have been reduced to normal background levels and most of the waste has been isolated from workers and the public, removed from contact with the environment, and placed in a controlled situation.

6. CONCLUSIONS

It is concluded that the principal objectives of the project were achieved. Decontamination to normal background levels was achieved in all areas of the site where remedial measures were undertaken. No significant adverse radiological or environmental impacts resulted from the operation. Some positive benefits were gained. The success of the project is attributable in part to extensive preplanning. Preparation of an Environmental Screening Document aided the planning by identifying areas of concern in advance.

ACKNOWLEDGEMENT

The authors wish to thank Dr. S.L. Iverson and Dr. K.K. Mehta for advice and assistance in the prepartion of this manuscript.

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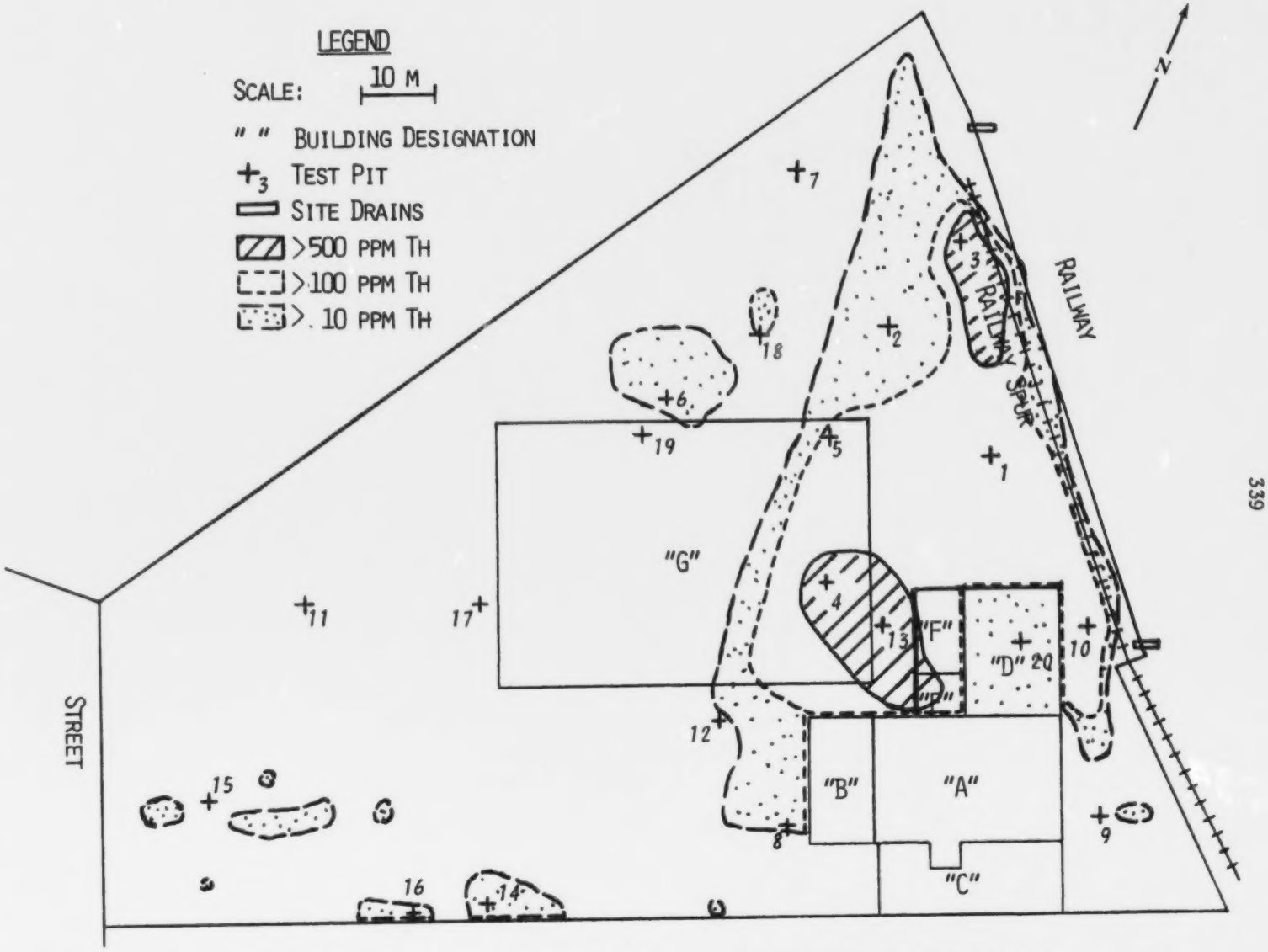

FIGURE 1: ESTIMATED THORIUM CONCENTRATIONS IN SOIL, INDUSTRIAL SITE, SURREY B. C.

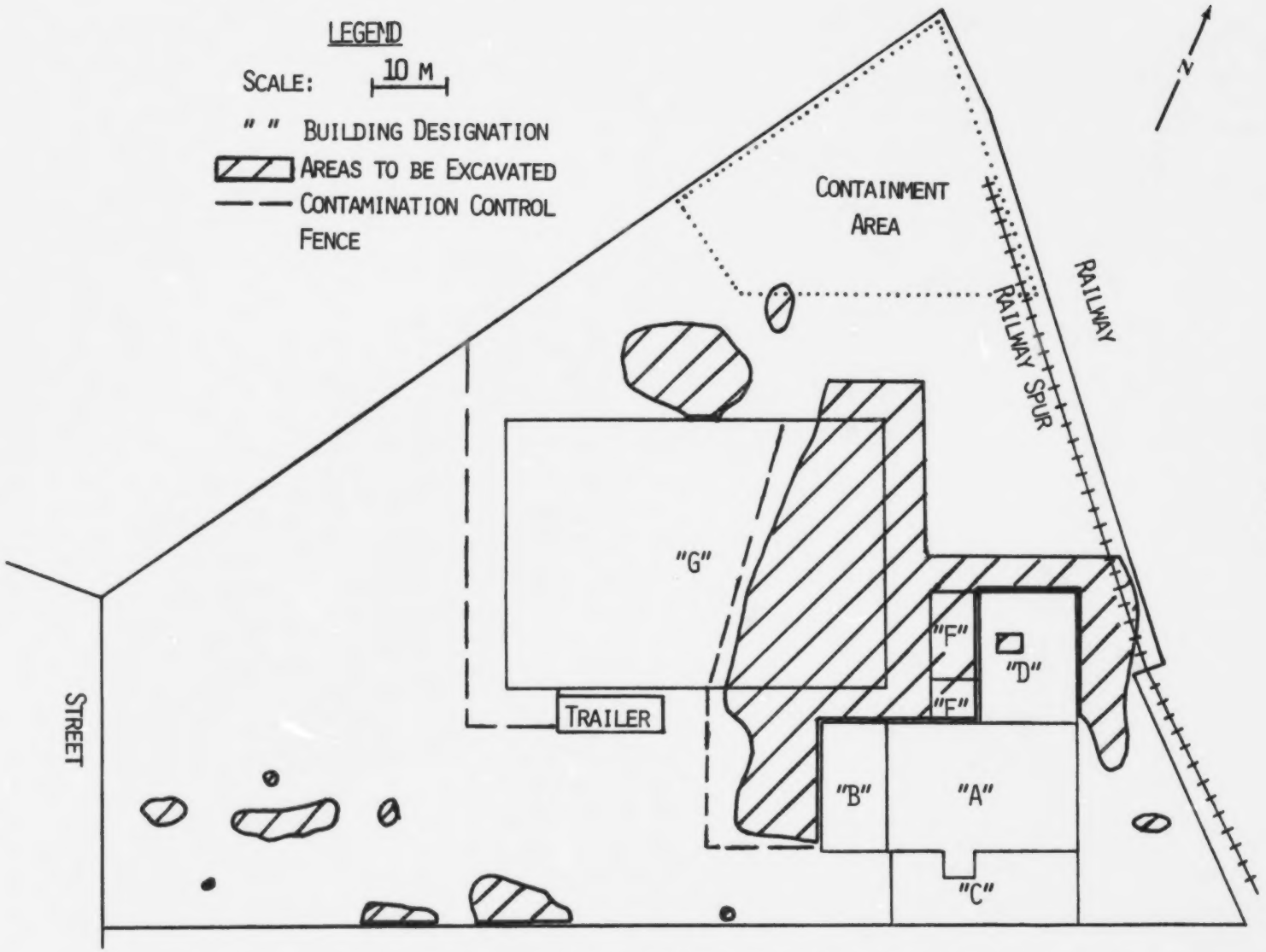

FIGURE 2: AREAS TO BE EXCAVATED UNDER THE AGREEMENT BETWEEN THE SITE OWNER AND THE FEDERAL GOVERNMENT

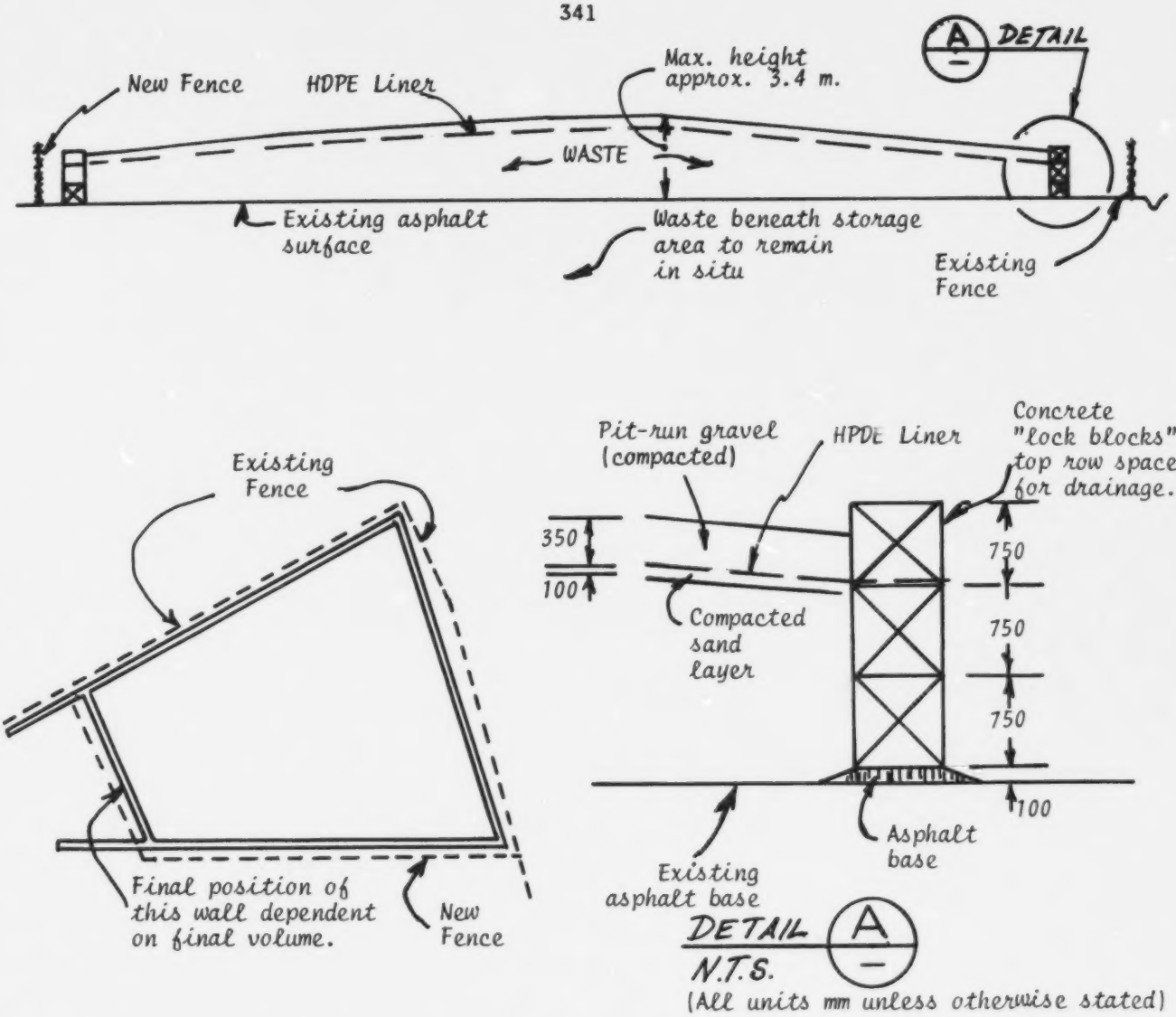

FIGURE 3: PLAN SKETCH AND SECTION OF WASTE CONTAINMENT, SURREY B. C.

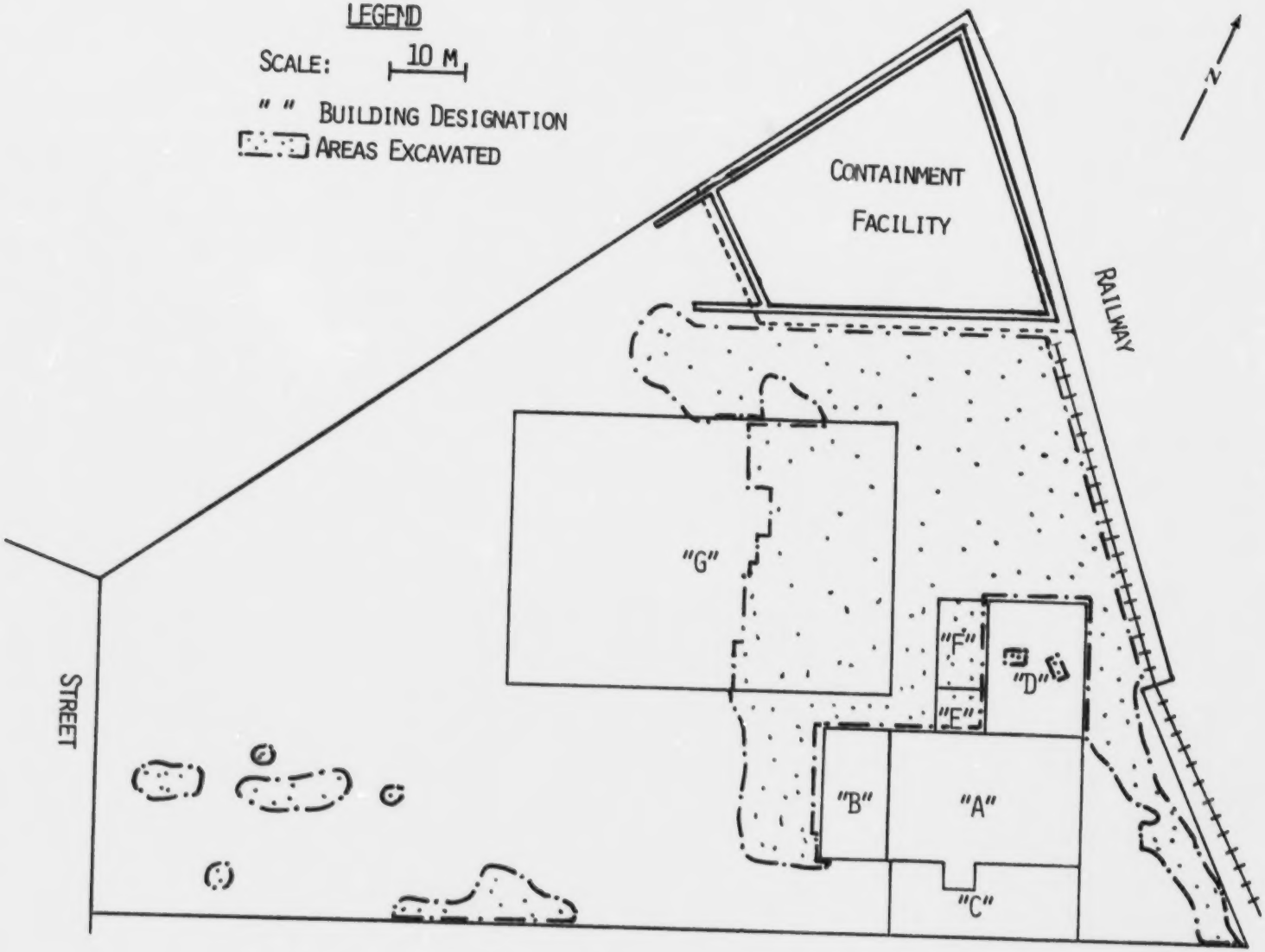

FIGURE 4: AREAS ACTUALLY EXCAVATED

DETERMINING CLEANUP GOALS: REALITY VS. POLITICAL MANDATE

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INTRODUCTION

Environmental legislation (1) has been with us for nearly two decades. During that time regulatory programs have focused on preventing or at least minimizing releases of toxic substances to the environment. Federal, provincial and state regulations for air, water and hazardous materials comprise uniform, applied standards, designed as preventive programs for currently operating and new industrial facilities. The stringency of these regulations often are much greater than is actually needed to protect public health and the environment for any one site or community. The standards developed within these programs are based on some level of acceptable and safe discharge. These discharge levels incorporate data about the inherent toxicity of specific compounds, fate of compounds as they move through air, water or soil, and susceptible populations within the vicinity of the source.

In spite of the success of these programs, as evidenced by cleaner environments throughout North America, different rules are being placed in newer statutes aimed at cleanup of contaminated sites. Having verified the existence of contaminated sites, the public no longer accepts goals that incorporate acceptable discharge levels, but rather demands absolute cleanup to zero contamination.

The question that must be resolved in any regulatory program addressing site contamination -- how clean is clean -- is basically a philosophical one. It is a question that has innumerable and equally valid answers. As a result, the legislative mandates for development of cleanup programs are often driven by political and emotional rhetoric and are conflicting.

This paper reviews the U.S. Comprehensive, Environmental Response and Compensation, Liability Act (CERCLA) as an illustration of a major cleanup program. Conflicts in statutory mandates are highlighted, noting the difficulties posed in setting cleanup goals that meet public demands. Alternative approaches for establishing cleanup goals are presented.

POLITICAL MANDATES FOR CLEANUP GOALS

The CERCLA was the first attempt in North America to Federally address problems of abandoned contaminated sites.(2) This legislation presented three mandates to the U.S. Environmental Protection Agency (US/EPA).

Mandates Established in 1980

The U.S. Congress required that remedial actions should be

a) permanent in nature,
b) protective of public health and the environment, and
c) developed within specific cost constraints.

For example, when defining the term remedy or remedial action, the U.S. Congress referred to

> "those actions consistent with permanent remedy...to prevent or minimize the release of hazardous substances so that they do not migrate to cause substantial danger to present or future public health or welfare or environment. (CERCLA, Section 101.)"

The legislative language imposes additional constraints on the development of cleanup goals by requiring that the US/EPA

> "provide for the cost-effective response which provides a balance between the need for protection of public health and welfare and the environment at the facility under consideration, and the availability of amounts from the Fund... (underline added for emphasis; CERCLA, Section 101(c)4.)"

By imposing this balancing requirement, the U.S. Congress did acknowledge, at that time, that the result might be incomplete cleanup at any particular site.

Although the first two mandates of CERCLA (i.e., permanent remedies and protection of health and the environment) are quite vague, it is likely that a regulatory program could have been developed that engaged the public's confidence. Cleanup goals could have been established using risk analysis. Permanent remedies then could have been evaluated in terms of the effectiveness in meeting those goals. However, when the conflicting requirements for both cost-effective responses and cost balancing were included, the public perception of program failure was inevitable.

The fund-balancing constraint dictates the type of protection that can be provided at any one site. Those technologies that are long-term and provide higher standards of cleanup usually are also the most costly. The issue is further complicated by the fact that a ceiling was imposed on the total amount of funds collected for implementation of the cleanup program. Consider three remedial choices for a particular site.

- Technology A achieves a set cleanup goal at a cost of $2 billion.
- Technology B meets the same level of protection but at a cost of $3 billion.
- Technology C provides a lower level of cleanup response at a cost of $1 million.

The most cost-effective choice in these examples would be Technology A. However, given an infinite number of sites in the program and a finite source of funds, a balance effort could lead to Technology C as the preferred action.

The question facing the US/EPA is whether to address the maximum number of sites at some minimal cleanup standard or to provide the maximum protection possible for a small number of sites with major contamination problems. Neither choice seems acceptable to affected communities.

As might be expected, the US/EPA has implemented a program that satisfies no one. Much of the Agency activity has focused on studies of the extent of contamination at a large number of sites and identifying responsible parties for cost-recovery purposes. The extent of remedial action has been limited to "surface removals" and on-site containment. Cleanup goals have been established on an ad-hoc basis and, as one might expect, are dictated by the cost of available technology. Cost and availability of remedial technologies are major determining factors. Risk analysis rarely enters the evaluation.

The problem inherent in the program is the impact that political and media pressures have in the process. The "squeeky wheel" tends to receive greatest attention. Because there is little continuity in decision-making, public perceptions are that some sites receive less attention (less stringent controls) than other, and that protection gives way to cost. Because of site-specific factors, comparisons among sites may not be justified. However, without apparent consistency in the decision-making process, such comparisons by the public will continue.

Mandates Set in 1986

In the political and highly emotional context that seems to direct environmental legislation in the United States, CERCLA reauthorization became a political football. Since 1983, reelection campaigns for a number of politicians have focused on the inadequacy of the cleanup program. U.S. congressional hearings were emotionally charged and rarely focused on the realities of the program: limitations of available technology, uncertainties inherent in monitoring data, uncertainties about health and environmental impacts, and cost constraints.

At no time has there been any attempt to evaluate the statutory mandates of the 1980 legislation as a means of understanding problems associated with implementation of cleanup goals. The result is a further complication in the process. The final reauthorization includes additional mandates to apply all existing environmental standards wherever appropriate.

Why does this new mandate complicate rather than resolve the problem? Certain factors make these standards inappropriate for full implementation in the CERCLA program. First, the concept around which these standards were developed is quite different from that of the cleanup goals. Each existing standard has been established based on risk assessments of potential exposures, relevant to the fate and transport within a specific environmental medium (e.g., air or water). Second, no one standard for a single

chemical suits all possible routes of exposure at a contaminated site. Third, these standards are designed for uniform application within a preventive program for current operation at all industrial facilities. Therefore, these standards often are far more stringent than actually may be necessary to protect health and the environment at any particular site within the CERCLA program. Finally, even if a mechanism were developed to apply existing standards at CERCLA sites, there are hundreds of toxic substances detected at abandoned sites for which no standards exist.

APPROACHES FOR ESTABLISHING CLEANUP GOALS

Although it is not possible to resolve the issue of "how clean is clean", it is possible and absolutely essential to develop a process for establishing site-specific goals. The ideal process would incorporate an essential element of consistency. Establishing consistency would go a long way toward re-establishing public confidence in the cleanup effort.

There are certain components that must be evaluated within the context of any approach. It is site-specific differences related to these components that determine appropriate cleanup levels. These components include

- Inherent toxicity of materials -- at any one site, toxicity levels among different chemicals will vary;
- Site conditions -- the hydrological, geological and climatic conditions at a site will determine potential migration routes and thus, potential exposure pathways;
- Assessment of risks -- toxicity and exposure routes determine the level of risk posed at any one site;
- Technological options - the site conditions will impact which technologies actually can be used.

Recently, the U.S. Congress Office of Technology Assessment (OTA) conducted a comprehensive analysis of the CERCLA program.(3) Specific options for developing greater consistency in decision-making process for site-specific goals were identified.

Site-specific Risk Assessment

This approach employs risk assessment to determine site-specific risks. In order to use this approach, it would be necessary to develop uniform methodologies for identifying the potential toxicity of chemicals, characterizing exposure pathways and calculating risk estimates. Such an approach also requires that acceptable levels of risks be identified: either acceptable individual risk or population risk. While it is not impossible for a regulatory agency to identify acceptable risk levels, given the emotional issues involved, a tough regulatory stance would be required to implement this option.

National Goals for Residual Contamination

This type of approach incorporates national standards for all chemicals or classes of chemicals found at a site. Existing standards, criteria and health advisories could be used as a basis for developing nationally applied standards. However, care must be taken in their use due to factors discussed previously. Expeditious implementation of this approach is hampered by the lack of data available for all hazardous substances. It also does not consider site-specific conditions or site-specific exposure pathways. However, the mandates for cost constraints and use of available technologies could be incorporated into this approach.

Clean to Background Levels

This option relies on the ability to determine "background" conditions. The cleanup goal of any particular site would be matched to environmental conditions resulting from other societal activities in the area. A major difficulty with this approach, however, is the ability to determine the background levels with any precision. Monitoring programs have limitations with respect to precision in sampling, analytical procedures, and interpretation of data. Historical environmental data are not available for much of the country and determining background levels will have to depend on current monitoring activities. This approach does not consider toxicity of the chemicals at a site, exposure routes or even potential health risks associated with a particular area.

Technology Based Standards

This approach is currently being developed within the authority of the U.S. Resource Conservation and Recovery Act. With such an approach all available technologies are evaluated to determine which one best minimizes concentrations of compounds found at a particular site. Identifying toxicity of any particular chemical or conducting risk assessments are not necessary activities. Information about site-specific conditions and knowledge of quantity/quality of contaminants are critical to successful application of the approach, however. These two factors determine which available technologies can be applied. It must be emphasized that no one technology is equally effective for all compounds potentially detected at a site. With this option, it would be necessary to impose some limits on cleanup costs, or to establish limits in the extent of remedial action. An advantage of this approach is that it precludes identifying risks and establishing risk-based cleanup goals.

Cost-Benefit Approach

This type of approach would require comparison of costs of remedial action with benefits derived for the protection of health and the environment. The preferred action would be the one for which benefits far exceeded cost. The difficulty with this approach, however, is the necessity to quantify benefits; a task that is inherently difficult and fraught with controversy. Agreement about dollar values associated with benefits is

difficult to achieve. It is not an impossible approach, but a standardized process would be needed that accounts for uncertainties associated with potential hazards, routes of the exposure, and actual risks expected. In other environmental programs (e.g., air and water), where use of cost/benefit analyses has been explored, the US/EPA has been reluctant to assign a required dollar value to public health protection. Implementation of this option can become very political.

Site Classification

This approach would identify cleanup goals based on identification of present or future use of a site. Classification based on potential use is not a novel idea and has been suggested for use in the US/EPA groundwater program. The approach, however, will be politically driven and could establish cleanup goals that do not reflect actual risks to public health and the environment. An advantage is that the extent of cleanup would be determined indirectly by local government officials, as they are responsible for determinations of future land use.

There are difficulties for implementing an approach such as this, as controversies about potential uses of a site emerge. Current controversy surrounding use of classification systems in groundwater programs centers on potential for changes in future use of the resource. An aquifer not usable now could be made usable in the future. Likewise, land currently designated for a parking lot or airport could be changed to farm applications at a future time. No one wants to lock out future possibilities. In addition to the need to resolve political disputes, some constraints on cost would be essential. A mechanism would be needed to balance the cost of cleanup against the measures of what the future use will be, or against the uncertainties of future uses. Again, it is not a clear-cut area of development. Of all of the approaches identified in the OTA study, this one is the most susceptible to political changes.

CONCLUSION

How clean is clean is a philosophical question that can never be conclusively answered. However, even within legislative constraints such as that posed in the CERCLA legislation, regulatory programs can be developed that enable decisions about cleanup goals.

The options identified by the OTA study are very different. The choice of any one will depend on which component or components become of major concern. However, the advantage of applying any one is that consistency is incorporated into the program. Without consistency, cleanup actions continually will be perceived by the public as inadequate for protecting public health and the environment.

REFERENCES

1. These include Canadian and U.S. legislation such as Transportation of Dangerous Goods Act, Hazardous Contaminants Act, Clean Air and Water Acts, Toxic Substances Control Act and Resource Conservation and Recovery Act.

2. Comprehensive Environmental Response and Compensation, Liability Act of 1980, Public Law 96-510.

3. U.S. Congress, Office of Technology Assessment, Superfund Strategy, (Washington, D.C.) 1985.

PROCESS DEVELOPMENT STUDIES LEADING TO THE DESIGN OF A FULL SCALE LEACHATE TREATMENT PLANT

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ABSTRACT

Laboratory and pilot scale treatability studies were conducted on a high-strength landfill leachate. The anaerobic filter followed by an aerated polishing lagoon achieved the best results. This paper summarizes the results of the laboratory and pilot scale testing of this treatment system. Results are also presented from monitoring studies of leachate generation and treatment in the existing anaerobic lagoons. These studies were used to define the design parameters for a full scale treatment plant now under construction.

INTRODUCTION

The Highway 101 Landfill site is located about 33 km from Halifax between Sackville and Mount Uniacke on Highway 101. The site is operated by the Metropolitan Authority and receives approximately 1,000 tonnes of refuse per working day. The site contains about 145 hectares of which 30 hectares are cleared. The daily cover material and liner is excavated from on-site glacial till material with a permeability of 10^{-6} cm/s or less. The landfill has been in operation since late 1977 and since that time more than one million tonnes of solid waste have been deposited to a maximum depth of 17 m. The base of the fill is underlain by a herring-bone pattern of leachate collector pipes which lead to the on-site treatment facilities. The leachate is at present treated in two anaerobic lagoons and then is discharged to a series of four siltation ponds thence into a swamp adjacent to the Sackville River.

In 1982 the Metropolitan Authority retained Porter Dillon to undertake an environmental review of the landfill site and its environmental systems. At this time the treatment system consisted of two aerated lagoons functioning in series. Problems had arisen in the operation of the lagoons as follows:

1. The lagoon liners had been displaced by a high groundwater table and had disrupted the aeration system. The high groundwater table continued to be a problem with the lagoons.
2. The aeration system, although restored, was suffering from clogging problems as a result of the high total dissolved solids in the leachate.
3. The strength and volume of leachate entering the lagoons exceeded the design loading and the aeration system could not maintain aeration levels within the lagoons.

The leachate in 1982 had a strength of 28,000 mg/1 COD and 22,000 mg/1 BOD. Given these strengths, Porter Dillon recommended that the Metropolitan Authority undertake treatability studies to ascertain the optimum form of treatment of this leachate.

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LEACHATE GENERATION

Leachate generation has been reported in literature by a number of authors to be variable both in quantity and quality. Leachate quality will be affected by the nature of the landfill as well as the nature of the refuse. Generally, the strength of the leachate will increase with the depth of the landfill and will decrease with the age of the landfill. The quantity of leachate generated is generally affected by the type of soil cover applied, the method of its application and the aerial extent of the landfill itself.

The highly variable nature of leachate generation and the inadequacy of past monitoring data at the landfill necessitated a one year monitoring study. Leachate generated in the landfill and collected by the collector system was quantified using a weir placed in the collector main. Data was collected at random intervals together with regular leachate samples for quality definition. The leachate flow data are plotted for the duration of the monitoring period in Figure No. 1. The flow is relatively stable from day 0 to day 174. After this point the flow rate appears to become erratic. This is probably due to sampling error as these data are based on simple random and instantaneous measurements of the rate of flow. Flow data were also gathered on a more continuous basis and are represented by monthly mean flows and standard deviations (Table 1). Since infiltration was anticipated in the portion of the collector between the landfill and the lagoons, flow data were not collected within two days of heavy rainfall.

The collected data represents a base flow of leachate generated in the landfill. Assuming that infiltration and inflow of surface water can be eliminated, a flow of approximately 1 1/s or less may be anticipated from the existing landfill. Since leachate generation is an areal phenomena, it is anticipated that with the expansion of the landfill to an area of 20 to 25 hectares, that the leachate generated will increase to approximately 1.66 1/s upon completion of the landfill operation.

Data were collected on the quality of leachate eminating from the collector main and from the existing treatment lagoons which converted to anaerobic operation prior to the study. Eleven (11) samples were collected at approximately equal intervals over the duration of one year. Chemical analysis for over 40 different parameters were carried out by the environmental chemistry lab at the Victoria General Hospital in Halifax. Selected parameters are depicted for raw leachate in Table 2.

The average COD of the raw leachate was 22,845 mg/l and at no time did it exceed 24,000 mg/l. The BOD of the raw leachate averaged 16,118 mg/l which gives a BOD to COD ratio of 0.7, indicating that the leachate is largely biodegradable. However, biodegradability will depend upon other components in the leachate such as trace nutrients, toxic contaminants and pH. The pH of the leachate was 5.6, considered below optimum for both aerobic and anaerobic treatment. The low pH is attributable to volatile acids such as acetic, propionic and butyric acids which comprised approximately 66% of the total COD. Acetic, propionic, and butyric acids constituted 45%, 34% and 24% respectively of the total volatile acids based on analysis of two samples of leachate.

Nutrients are also an important aspect of biological treatment. Although total kjeldahl nitrogen (TKN) is high, it is predominantly a result of ammonia nitrogen concentration. Only about 25% of the TKN is due to organic nitrogen. Ammonia is present in concentrations sufficient to provide a nitrogen source for microbial growth without being toxic. The ratio of COD to nitrogen is 47:1. The phosphorus concentration was determined as total phosphates and

RAW LEACHATE FLOW

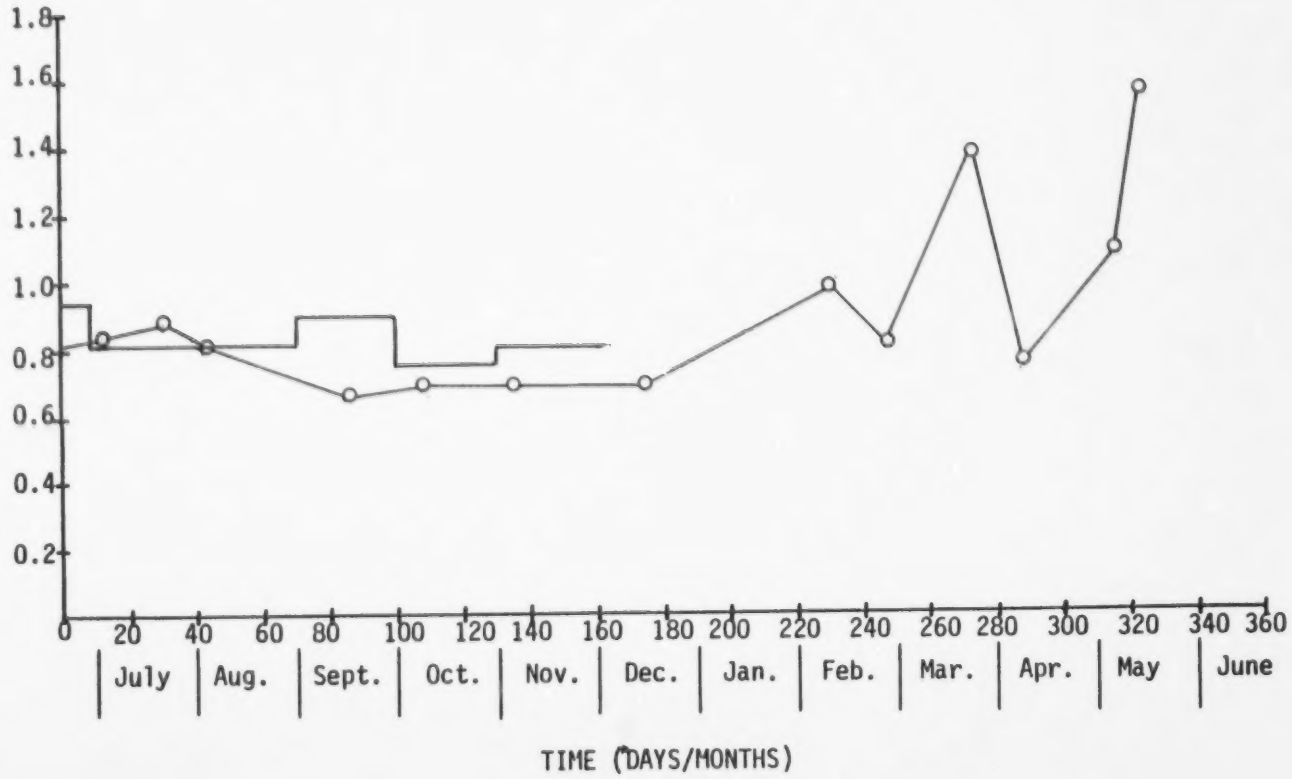

FIGURE NO. 1

TABLE 1

LEACHATE FLOW MONITORING DATA

MONTH	FLOW (1/s)		
	n	x	s
June	9	0.94	0.05
July	10	0.81	0.08
August	13	0.80	0.10
September	11	0.89	0.14
October	9	0.75	0.12
November	6	0.80	0.00

NOTES:

1. n - number of samples; x - mean; s - standard deviation.

TABLE 2

LANDFILL LEACHATE QUALITY

PARAMETERS: (mg/l)	n	x	s
pH (units)	6	5.60	0.13
COD (total)	11	22845	1445
BOD	11	16118	1937
TOC	11	8136	967
TKN	10	490	102
Ammonia	11	370	18
Nitrate, Nitrite	11	< 0.5	-
Total Phosphate	10	9.12	3.51
Ortho-Phosphate	11	0.45	0.54
Total Solids	11	15734	951
Total Dissolved Solids	11	15297	1103
Total Volatile Solids	2	6187	-
Humic Acids	0	416	46
Total Volatile Acids	2	10100	-
Calcium	9	1741	105
Alkalinity	11	3850	357
Sulphate	11	831	70
Hardness	11	5423	306
Metals - iron	10	937	99
zinc	10	68.3	7.8
nickel	10	0.48	0.15
manganese	10	58.9	5.8

NOTES:

1. n - number of samples; x - mean; s - standard deviation.

ortho-phosphates. Total phosophates in raw leachate averaged 9.12 mg/1 as phosphate, which is equivalent to about 3 mg/1 as phosphorus. This gives a COD to phosphorus ratio of 7,615:1, which is regarded as providing insufficient phosphorus for microbial growth in a biological treatment system. However, ratios as high as 4,360:1 have been used (Chian and DeWalle, 1977).

The leachate produced at the landfill is typically high in total solids with a large portion of these solids (97%) being present in the dissolved form. This indicates that a significant fraction of the solids (50%) will be available for microbial use as a soluble energy source. The low levels of suspended solids should not constitute a clogging problem. The high hardness of the leachate 5,423 mg/1 has posed a considerable problem to the fine bubble aeration system present in the lagoons. Aeration systems treating leachate should be submerged coarse bubble aerators or turbine aerators. Although alkalinity of raw leachate is high, it should be noted that the pH is only 5.6 and therefore a considerable portion of the buffering capacity is due to volatile and humic acids as well as carbonate mediated alkalinity.

Metals are a normal component of leachate. Iron is the most highly concentrated metal but is not noted to be toxic. However, iron precipitates may cause damage to piping equipment and foul check valves, thus iron concentration should be decreased if possible. Zinc concentration is also high and zinc has been noted to be toxic when soluble. Inhibition has been noted at concentrations of .5 mg/1 in anaerobic digestion, but anaerobic filters have been operated at higher zinc loadings (Rivera, 1983; DeWalle et al, 1979). The other metals present in the leachate are not known inhibitors at their respective concentrations nor do they present any physical problems.

LEACHATE TREATMENT

Anaerobic Lagoons

The biological activity in the lagoons generally starts in May and increases through to September. Visible gas production appears to decrease from September until ice cover. In the spring, after the ice recedes, visible gas production is very low. At this time the lagoons have changed from a black to an orange brown colour which remains until the anaerobic activity increases.

The effluent from the two anaerobic lagoons were monitored with 11 samples over 12 months. The best performance was achieved in the effluent of lagoon #2 in February when the COD removal of 68.5% was recorded. However, lagoon #1 was generally responsible for 92% of the removal achieved. Thus, lagoon #2 added little to the overall process. The effluent from lagoon #2 averaged 10,044 mg/1 of COD during the monitoring study which is equivalent to an average COD reduction of 66% by the two lagoons.

Laboratory Studies

A model treatment system consisting of an anaerobic reactor at 32°C and an aerated lagoon at 20°C was established at the Technical Univeristy of Nova Scotia. The anaerobic filter was a cylinder 0.9 m in depth with a total volume of 12.85 1; the total liquid volume was 11.35 1. Medis occupied 1.5 1 and the volume of the mixing chamber below the media support plate was 2.35 1. Thus, the volume of liquid in the effective portion of the reactor was 9 1 (effective reactor volume 10.5 1). The media which consisted of 25 mm ceilcote tellerettes was supported on a media support plate. The media was randomly placed and because of its filamentous structure was less likely to

produce dead space and short circuiting in the reactor. The media had a specific surface of 180 m^2/m^3 and a free volume of 87%.

Recirculation was accomplished using a peristalic pump which recirculated reactor contents at a rate of 0.165 l/m in an upflow fashion. The recirculation system was operated to achieve 14 recirculations per day of the total volume. The recirculation to feed ratio was approximately 250:1.

The aerated lagoon consisted of a two chambered aquarium having a total volume of 21.1 l. Air was supplied from an aquarium aerator through two diffuser stones. A settling lagoon identical to the aerated lagoon, but without aeration, was operated in parallel to the aerated lagoon at the same loading.

The anaerobic filter was started with a mixture of equal parts of anaerobic lagoon effluent, raw leachate and an anaerobically digested primary sludge brought to a neutral pH. The aerated lagoon was seeded with a mixture of raw leachate, distilled water, anaerobic filter effluent, and aerobic digester sludge in a ratio of 1:4:4:1. The settling lagoon was started with a mixture of distilled water and anaerobic filter effluent.

A start-up and transition period extending over 30 weeks was utilized to ensure that the treatment system was operating under stable conditions. During these periods the treatment system was fed a leachate which had been pre-treated by the addition of lime to neutralize the pH and phosphate to increase the COD to phosphorus ratio to 1,000:1. Following addition of the lime, the leachate was allowed to settle one hour to remove the sludge which was formed, after which the phosphate was added immediately prior to administering the feed stock to the reactor. More detailed information on the experimental design and results is available (Thirumurthi et al, 1986).

Leachate feedstock quality is depicted in Table 3. Comparison of the leachate feedstock quality with the raw leachate quality reveals that there is no difference between the two leachates with respect to organic parameters or nutrients (except phosphate). Phosphates were precipitated in the sludge by lime addition, but were replenished by the addition of phosphates following the removal of the sludge. Treatment by pH neutralization reduced the total zinc concentration to typically less than 8 mg/l. This range of zinc concentration has not been shown to be toxic and no affects were observed in the results of the reactors. It is suspected that the zinc remaining in solution may have been in the form of a fine, insoluble precipitate.

The experimental conditions and loading of the reactors are depicted in Table 4. During this experiment the anaerobic filter was operated in series with the aerated lagoon as one system and then with the anaerobic filter in series with the facultative lagoon as another system. The aim of this was to determine whether or not aeration was required to improve the effluent from the reactor system. The results depicted in Table 5 were collected over a period of three weeks after five weeks of stable operation. It can be seen that COD, BOD and TOC were greatly reduced within the anaerobic filter which achieved efficiencies of 97%, 98% and 99% respectively. The reactor achieves a 78% reduction in total solids and dissolved solids, while total volatile solids are reduced by 92%. Total kjeldahl nitrogen was reduced by 16%, while ammonia appears to have been unaffected. The reactor as well achieves a 98% reduction of iron and an 88% reduction of zinc, probably through a process of co-precipitation with the dissolved solids within the reactor. The high ammonia in the effluent points to the need for post-treatment of the anaerobic filter effluent.

The aerated lagoon achieved a greater reduction of COD, BOD and TOC than the settling lagoon (Table 6). As well, there was a greater reduction of

TABLE 3

LEACHATE FEEDSTOCK QUALITY DURING THE
4 PHASES OF THE MODEL STUDY

	Settled Feedstock		
PARAMETERS: (mg/l)	n	x	s
COD	10	21760	1530
BOD	7	16929	1257
TOC	3	9933	1379
TKN	5	470	37
Ammonia	5	380	17
Nitrate, Nitrite	5	< 0.5	-
Total Phosphate	5	4.4	1.3
Ortho-Phosphate	5	< 0.2	-
Total Solids	5	19514	3000
Total Dissolved Solids	5	19176	3014
Total Volatile Solids	1	8600	-
Humic Acids	2	402	-
Total Volatile Acids	2	10800	-
Alkalinity			
Sulphate	3	194	82
Metals - iron	5	3.96	1.83

NOTES:

1. Raw leachate brought to pH 8.0 and settled one hour; no phosphate supplemented in sample, but added prior to feeding.
2. n - number of samples; x - mean; s - standard deviation.

TABLE 4

EXPERIMENTAL CONDITIONS AND LOADING IN REACTORS
WEEKS 5 to 8

PROCESS	ANAEROBIC	AEROBIC	
REACTORS	Filter	Lagoons	
		Aerated	Settling
Parameters			
Influent COD (mg/1)	21760	693	693
Hydraulic Load (1/d)	0.95	0.3	0.2
Reactor volume (1)	11.35 (10.5)	21.1	21.1
Detention time, HRT (days)	12	70	106
Volumetric organic load ($kg/m^3/d$)	1.97[1]	0.01	0.007
Final Effluent COD (mg/1)	693	142	325
Efficiency (as % removal)			
COD	97	80	45
BOD	98	98	94
TOC	98	74	46

NOTES:

1. Based on effective volume of 10.5 1.

TABLE 5

REACTOR EFFLUENT RESULTS
WEEK 5 TO 8 AT TEMPERATURES INDICATED

REACTOR	Anaerobic Filter (32°C)				Aerated Lagoon (20°C)			
PARAMETERS: (mg/l)	n	x	s	%	n	x	s	%
Organic Load ($kg/m^3/d$)	-	0.197	-	-	-	0.01	-	-
COD	4	693	293	-97	4	142	6	-80
BOD	4	254	94	-98	4	4.25	1.71	-98
TOC	4	224	35	-98	4	59.0	9.3	-74
TKN	4	395	21	-16	4	6.48	0.91	-98
Ammonia	4	382	9	+ 1	4	1.30	1.46	-99
Nitrate, Nitrite	4	0.50	-	0	4	138	19	+27500
Total Phosphate	4	5.20	0.85	+18	4	3.00	0.08	-42
Ortho-Phosphate	4	0.82	0.48	+310	4	2.08	0.26	+153
Total Solids	4	4296	96	-78	4	3537	66	-18
Total Dissolved Solids	4	4220	90	-78	4	3497	83	-17
Total Volatile Solids	4	714	59	-92	4	414	18	-42
Humic Acids	2	373	-	-	2	230	-	-38
Total Volatile Acids	4	55	-	-99	4	20	-	-64
Calcium	2	108	-	-	2	86	-	-20
Alkalinity	2	2895	-	-	2	812	-	-72
Sulphate	2	28	-	-	2	210	-	+650
Metals - iron	4	11.8	3.3	-98	4	0.36	0.18	-97
zinc	4	0.52	0.12	-88	4	0.13	0.02	-75
copper	2	0.10	-	-	2	0.10	-	0
manganese	2	0.60	-	-	2	0.10	-	-83

NOTES:

1. % is the percent change in a parameter relative to the influent concentration.
2. n - number of samples; x - mean; s - standard deviation.

ammonia and TKN. In the settling lagoon (Table 6). These were not converted into nitrate, while in the aerated lagoon, nitrates were greatly increased in the effluent. Total solids removal was also much more efficient in the aerated lagoon than in the facultative lagoon and in general, the effluent from the aerated lagoon was considerably better in appearance, odour and quality than that from the facultative lagoon.

When comparing the results of the anaerobic filter with the effluent achieved at a 1 kg loading during previous operating phases (Thirumurthi et al, 1986), it is significant that there is no deterioration in effluent quality between a 1 and a 2 kg loading. This implies that at less than 2 kg COD/m^3/d load, the filter is underloaded and does not reach its full potential. Although the optimum load is not fully defined, it appears that it will be a higher COD loading than 2 kg/m^3/d. Furthermore, until the anaerobic filter is brought to its optimum load, the aerated lagoons will be underloaded as well and an economic system will not be achieved. It is also apparent that aeration, although expensive, is necessary to produce a clear high quality effluent. If nitrogen control is necessary, then ammonia stripping should occur before the effluent enters the aerated polishing lagoon.

Pilot Studies

The laboratory studies had demonstrated that leachate was treatable using an anaerobic filter and aerated polishing lagoon. In order to study the anaerobic filter portion of the treatment system at higher loading and at a larger scale, the pilot National Research Council Canada (NRC) reactor plant was obtained. The NRC pilot plant consists of a 4.9 m long by 2.5 m wide mobile trailer containing an anaerobic downflow, stationary fixed-film reactor of NRC design. The trailer housed equipment to maintain temperature, record gas production and monitor reactor contents, as well as ancillary equipment for feed stock production and automatic feeding.

The anaerobic filter reactor had a total volume of 640 l of which media occupied approximately 70 to 80 l. The media was a 100% polyester geotextile fabric supported on stainless steel stretchers and suspended within the reactor. Reactor contents were recirculated (from bottom to top) in a downflow mode at a rate of 24 times per day resulting in a completely mixed system. The feed stock was pumped into the recirculation system at pre-determined intervals and at quantities determined by the loading requirements. The recirculation line also contained an electric heater which maintained the reactor contents at 35°C.

Raw leachate was pumped from the underdrain system into mixing tanks where it was pre-treated with lime slurry. Phosphates were not supplemented during this study and the COD and phosphorus ratio of the leachate was 7,615:1. During feed stock preparation lime slurry was added to raise the pH to 7.8, followed by one hour of settling. The sludge was drained and the supernatant was retained as feed stock. As in the previous study, chemical analyses were carried out at the environmental chemistry laboratory of the Victoria General Hospital in Halifax. A total of 15 parameters were monitored about twice per week and metal scans were performed bi-monthly. Volatile acid analysis was performed by NRC in Ottawa and gas sample analysis was performed at NRC's Atlantic Reserch Laboratory. Wright et al, 1985, presented details of experimental design and results.

The pre-treatment procedure was based on pre-treatment jar test results (Thirumurthi et al, 1986) and was intended to neutralize pH while minimizing inhibitory affects of heavy metals such as zinc. Comparison of Tables 7 and 2

TABLE 6

REACTOR EFFLUENT RESULTS
WEEKS 5 TO 8 AT 20°C

Reactor	Settling Lagoon			
PARAMETERS: (mg/l)	n	x	s	%
Organic Load ($kg/m^3/d$)	-	0.007	-	-
COD	4	325	32	-53
BOD	4	15.3	3.8	-94
TOC	4	120	14	-46
TKN	4	48.8	6.9	-88
Ammonia	4	37.5	4.4	-90
Nitrate, Nitrite	4	0.50	-	0
Total Phosphate	4	6.95	2.03	+33
Ortho-Phosphate	4	5.60	0.57	+582
Total Solids	4	4142	37	- 4
Total Dissolved Solids	4	4132	38	- 2
Total Volatile Solids	4	611	52	-14
Humic Acids	2	354	-	- 5
Total Volatile Acids	4	27.5	9.5	-50
Calcium	2	27	-	-75
Alkalinity	2	1800	-	-38
Sulphate	2	62	-	+120
Metals - iron	4	1.39	0.36	-88
zinc	4	0.11	0.01	-79
copper	-	0.10	-	0
manganese	-	0.10	-	-83

NOTES:

1. % is the percent change in a parameter relative to the influent concentration.
2. n - number of samples; x - mean; s - standard deviation.

TABLE 7

CHEMICAL ANALYSIS OF LEACHATE FEED STOCK

PARAMETER	n	x	s
COD - total	33	23463	2931
- Soluble	32	22201	2068
TOC	31	8374	797
TVA	32	10511	1162
VA - acetic	10	4629	426
- butyric	10	2012	203
- propionic	10	3226	223
Humic Acids	28	407	54
pH		7.6-7.8	
TKN	32	455	29
Ammonia	32	386	21
Nitrate/Nitrite	31	<0.5	-
Phosphate - total	32	4.88	2.62
- ortho	30	<0.2	-
Total Solids	32	19325	1874
Total Dissolved Solids	32	18816	1183
Total Volatile Solids	31	8188	549
Suspended Solids	32	509	-
Alkalinity	32	4875	457
Calcium	2	2838	-
Sulphate	32	815	69.6
Metals - Fe total	12	560	214
- Mn total	12	50.1	10.0
- Zn total	12	15.4	13.0
- Cu total	12	<0.1	-
- Pb total	12	<0.02	-
- Ni total	11	0.39	0.12
- Zn soluble	1	0.35	-

Notes: 1. all units in mg/l except pH (note - pH range provided, not a mean value)

2. n = number of samples, x = mean, s = standard deviation

TABLE 8

REACTOR CONTENTS DURING THREE WEEKS OPERATION
AT A 3.61 kg/m^3/day LOAD

PARAMETER	n	x	s	% ALTERATION
COD - total	4	1717	1122	- 92.6
- soluble	4	1324	898	- 94
TOC	2	840	-	- 90
TVA	4	320	-	- 97
VA - acetic	4	236	8.5	- 95
- butyric	4	79	2.5	- 96
- propionic	4	0	-	-100
Humic Acids	1	445	-	+ 9
pH		7.26 - 7.5	-	-
TKN	5	423	65	- 7
Ammonia	5	423	50	+ 10
Nitrate/Nitrite	5	<0.5	-	0
Phosphate - total	5	7.90	4.61	+ 62
- ortho	5	0.82	0.58	+300
Total Solids	5	4678	482	- 76
Total Dissolved Solids	5	4185	633	- 78
Total Volatile Solids	5	1119	338	- 86
Suspended Solids	5	132	45.5	- 74
Volatile Suspended Solids	3	69.7	24.0	-
Alkalinity	5	2816	209	- 42
Calcium	-	-	-	
Sulphate	1	10.0	-	- 99
Metals - Fe total	1	19.0		- 97
- Zn total	3	1.11	0.54	- 93
- Zn soluble	4	0.17	0.09	- 50

Notes: 1. all units in mg/l except pH
2. N = number of samples, X = mean, S = standard deviation

reveal that pre-treatment reduced metal concentrations to acceptable levels, successfully adjusted pH, but had no affect on COD, total volatile acids (TVA) or nitrogenous nutrients.

Three separate loading rates were tested in the NRC anaerobic filter. The loading consisted of a four week stable period at a volumetric organic load of 3.61 kg COD/m^3/d with consistent gas production and effluent quality with feed stock administered six times per day. Table 5 depicts the results of the last three weeks of operation at this loading. At all three loadings COD concentrations were reduced by greater than 92%, while TVA concentrations were reduced by at least 97% at each of the loadings. The effluent volatile acids were dominated by acetic acid while propionic acid was completely utilized. Althought phosphates were not added to the feed stock, the sludge that was present in the reactor due to the seeding of the reactor and due to previous utilization of the reactor on fish wastes, provided sufficient phosphorus to create elevations of these elements in the reactor contents.

Although raw leachate is high in total solids, most of these are present in the dissolved form. Pre-treatment significantly increased dissolved solids concentrations. The anaerobic reactor achieved between 76 and 79% reduction in the total solids concentrations. It is estimated that about 39% of the total solids will be retained in the reactor as inert solids in the sludge. Since metals are also retained in the reactor, possibly through a mechanism of co-precipitation, it is anticipated that the sludge will be metal laden and therefore has potential to create a toxic inhibition. This has been noted by other authors (DeWalle et al, 1979). Metal toxicity was thought to be inhibiting the activity of the anaerobic filters during the laboratory studies (Austin et al, 1984). Zinc was present as fine precipitates of sulphide or carbonate with little present in the soluble form. Other metals were also removed by the reactor, although they were not considered to be present in inhibitory concentrations. This points the need to a sludge removal mechanism to prevent the inhibitory build-up of metals within the reactor.

Gas analysis indicated that the loading did not affect gas composition. Gas composition was consistently about 72% methane, 26% carbon dioxide, with the remainder being other gases. Approximately 3.9 l of methane were produced per gram of COD removed at all loadings.

CONCLUSIONS

The anaerobic filter was capable of 92% and 97% reduction of COD and TVA respectively at loading rates up to 3.6 kg COD/m^3/d. Total solids and metal concentrations were reduced in the reactor, resulting in the accumulation of a metals laden sludge. At a 2 kg loading, both reactors responded in a similar fashion, achieving approximately a 95% to 96% reduction in COD. It is impossible to say whether the addition of phosphates is necessary or not. However, it is possible that phosphates may be necessary at higher loadings or during reactor upsets (Wright et al, 1985). More research is needed relative to the role of phosphorus in anaerobic high rate reactors. Higher loadings than 4 kg/m^3/d may be sustainable since the reactors did not reach their optimum point of loading. Further studies of this leachate by NRC Ottawa have revealed that higher loadings in excess of 12 kg COD/m^3/d are possible and that pH neutralization may not be necessary (Kevin Kennedy, NRC, personal comment, 1985).

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DETAIL DESIGN OF A HIGH RATE ANAEROBIC TREATMENT FACILITY FOR A LANDFILL LEACHATE HIGHWAY 101 LANDFILL HALIFAX COUNTY, NOVA SCOTIA

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ABSTRACT

Operational and environmental analysis of the Highway 101 Landfill identified the need for upgrading the leachate treatment facilities. A program of laboratory and pilot scale testing led to the design of the first high rate anaerobic leachate treatment facilities in Canada. Construction is in progress and start-up is expected in December of 1986. The treatment system consists of four stages including a pre-treatment stage, high rate anaerobic reactors to reduce organic strength, sludge handling facilities and polishing lagoons. The process schematic is presented to illustrate the various flow streams and the flexibility and options for process operation. Design sizing is discussed for each process component of the various treatment stages and details illustrating the anaerobic reactors along with facility and site layout are provided.

INTRODUCTION

The leachate generated at the Highway 101 Landfill site has been the subject of investigations extending over a three year period and culminating with pilot scale testing of its treatability utilizing innovative anaerobic treatment techniques. This paper describes the complete process of the full-scale facility which is expected to achieve a 95% reduction in strength of the raw leachate. The treatment system will consist of:

- pre-treatment to adjust pH and remove inhibitory metals
- anaerobic reactors for reduction of organic strength
- sludge handling facilities
- polishing lagoons

The facilities will, for the most part, be enclosed in a serviced building located at the base of the landfill and adjacent to the existing lagoons.

Leachate flows and quality were determined from previous sampling and analysis programs conducted by Porter Dillon Limited. Future characteristics were predicted based on the expected increase in landfill area utilization as well as refuse deposition over time. Increases in leachate flow relate linearly to the increase in landfill area coverage as leachate collection pipes will continue to be laid below developing portions of the site. Future leachate quality was determined by means of a model which assumed that 10 years after its placement, refuse ceases to contribute organic constituents to the leachate.

The influent leachate characteristics utilized for design may be summarized as follows:

- present design flow = 1 l/s;

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- future design flow = 1.75 l/s;
- present COD load = 1,815 kg/d, and
- future COD load = 2,400 kg/d.

The site positioning of the treatment facilities was selected to make best use of existing leachate collection and treatment infrastructure. The site plan of Figure No. 1 illustrates the layout of the facilities relative to the existing lagoons and access road. The access road will be upgraded to accommodate the increased traffic resulting from chemical supplies, sludge disposal and general operator requirements.

TREATMENT FACILITIES

The four stages of treatment along with associated works are illustrated in the process schematic of Figure No. 2. The primary and by-product flow streams along with the options for process variation are depicted. It was essential that as much operational flexibility as possible be incorporated in the facilities due to the limited experience with the high rate anaerobic treatment process. The components of each stage of treatment are described separately in the following sections.

Raw Leachate Pumping Station

Flow will be diverted from the existing leachate collection system to a pumping station consisting of submersible pumps and a pre-cast concrete wetwell of 3.6 m^3 operating volume. Two pumps will be provided, one to serve as stand-by, with each sized at a pumping rate of 10 m^3/hr. The pumps will be sufficient to handle the present and ultimate flow expected. An overflow/by-pass is to be provided from the pumping station to the lagoons for activation under particularly high flow or emergency conditions.

Pre-Treatment Facilities

The pre-treatment system will be comprised of an equalization tank, a caustic feed system and rapid mix, flocculation and settling units. Each of these components are designed to accommodate initial as well as ultimate flow conditions.

Equalization. A reinforced concrete equalization tank of volume 50 m^3 will equalize the influent flow (through its average and peak conditions) and plant recycle streams for a constant discharge through the succeeding units.

Caustic Addition. Caustic stored in a 14 m^3 bulk storage tank will be fed to the leachate flow following equalization in order to adjust pH and in turn control heavy metals' concentration. The high calcium concentration in the raw leachate discouraged the use of lime due to expected scaling problems. The actual caustic feed rate will be adjusted by means of pH control to maintain the pH in the flocculation tank at 7.8.

Rapid Mix and Flocculation. The rapid mix and flocculation tanks are sized for a detention time of 1.5 minutes and 15 minutes respectively. This results in a volume of 0.26 m^3 for the rapid mix tank and 2.6 m^3 for the flocculation tank. Both tanks will be fabricated of mild steel and coated inside and outside to prevent corrosion. The tanks will be covered and vented for control of odours.

The rapid mix tank will be complete with a 1/4 HP continuous duty mixer to achieve full mixing of caustic and leachate. The flocculation tank will be

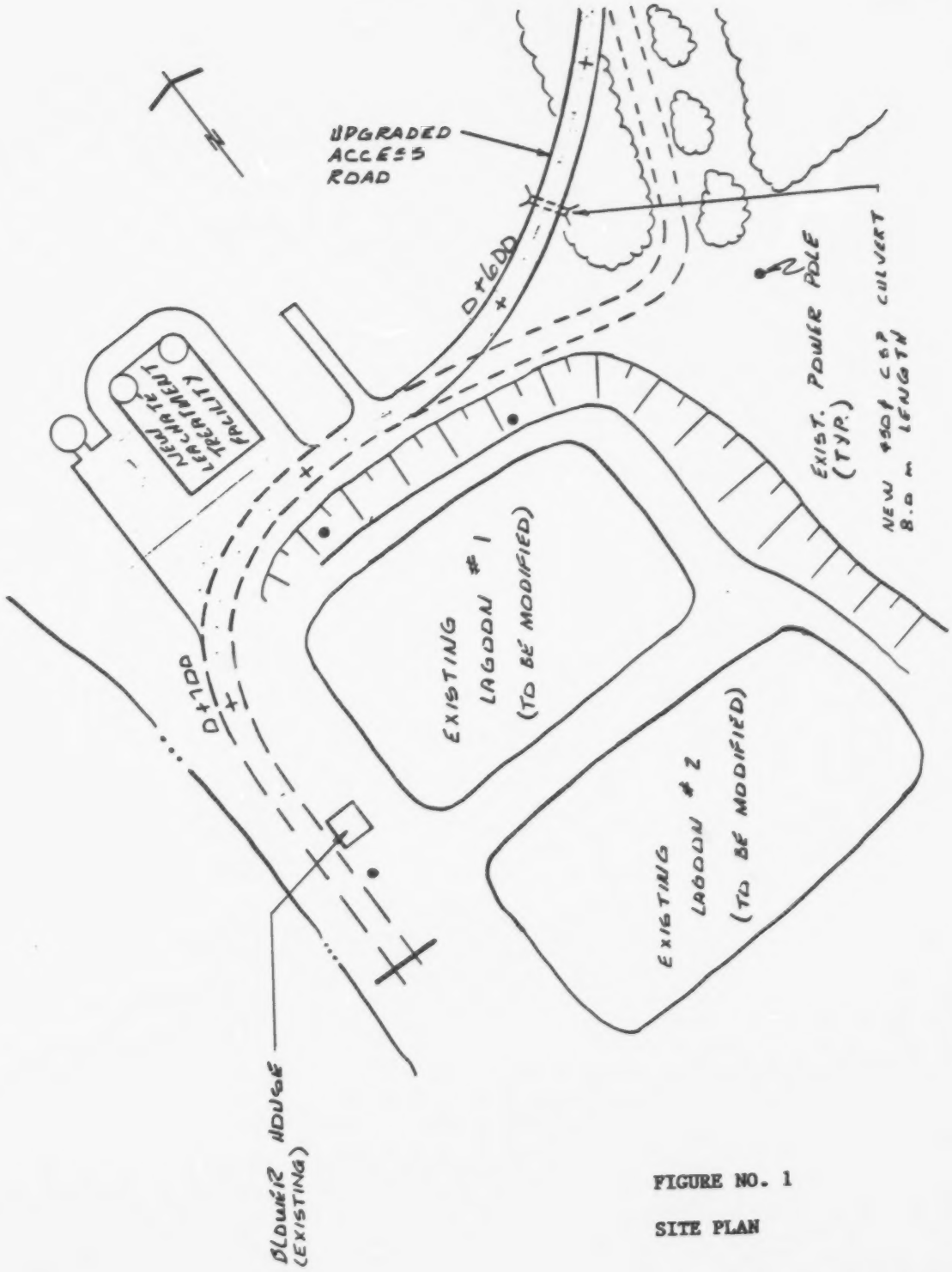

FIGURE NO. 1

SITE PLAN

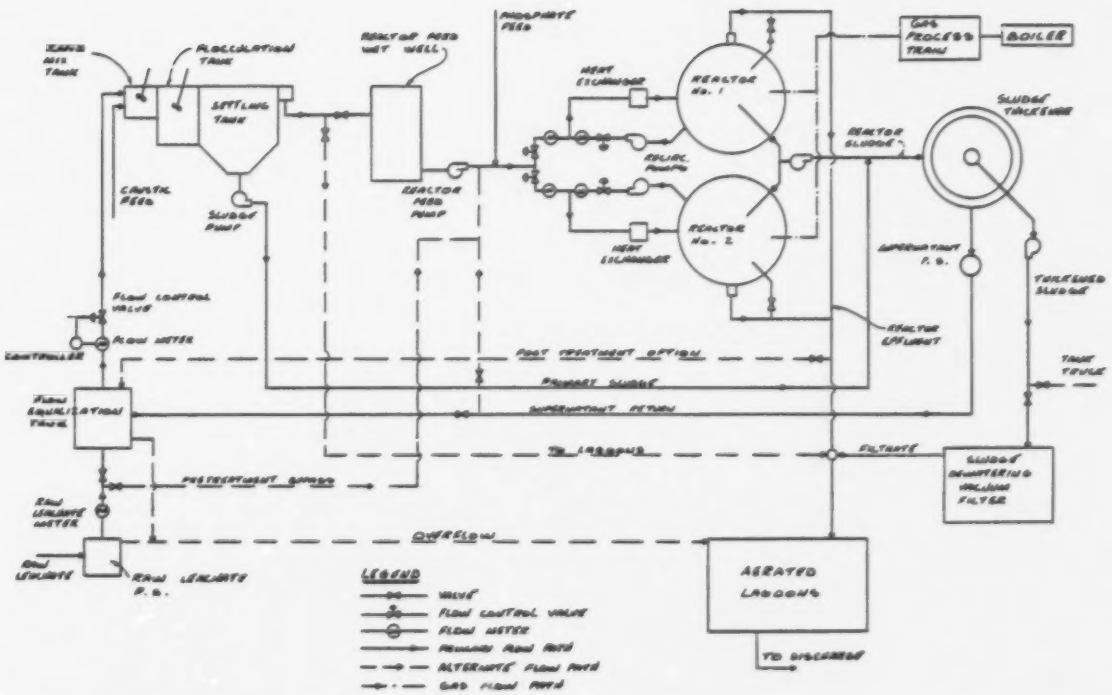

FIGURE NO. 2

PROCESS SCHEMATIC

installed with a variable speed 1/2 HP mixer providing gentle agitation to enable contact of chemical and metals in leachate as well as efficient adjustment of pH.

Settling. The settling tank is designed to handle both initial and ultimate flows. It will also be covered, constructed of mild steel materials with suitable protective coatings and will contain an effluent weir and scum baffle system. Sludge accumulating in the settling tank will be automatically removed on a time basis and conveyed to the sludge thickener by means of progressive cavity pumps.

Anaerobic Reactor System

The anearobic reactor system constitutes the primary facility process. The system includes the feed station, reactor vessels with their various components, recirculation system including heat exchangers and gas handling scheme.

Reactor Feed Station. Reactors will be fed on a semi-continuous basis allowing for flexibility of operation over the life of the facility. A 1.5 m diameter closed vessel will serve as the wetwell for the feed pumps. Duplex centrifugal pumps (one as stand-by) will convey pre-treated leachate to the reactors. The feed wetwell will be covered and vented through scrubbers to the atmosphere.

Anaerobic Reactors. Two upflow anaerobic reactors will be used to achieve the reduction of COD in the leachate. The two reactors are identical and designed to pass flow upwards through a sludge blanket and media layer before overflowing to effluent (and recirculation). The reactors will be circular in shape and sized at a diameter of 5 m with a 7 m sidewall depth. The effective volume of each reactor amounts to 135 m^3, resulting in loading rates under initial conditions of 7 kg COD/m^3/d and increasing to 9 kg COD/m^3/d under ultimate conditions. Should it be necessary to remove one reactor from operation for maintenance, cleaning or similar reason, all influent will be directed to a single reactor which is expected to adequately handle the additional temporary load.

Figure No. 3 presents a cross-section of the anaerobic reactor. Influent flow mixes with recirculated reactor contents and proceeds through a heat exchanger into the distribution piping at the bottom of the reactor. Flow moves upwards through approximately 2 m of an anaerobic sludge blanket and then through a 1 m transition area before entering the media. The media consists of a cross-flow block type media installed in a 3 m layer. Above the media is an overflow area for further clarification and degasification of the liquid before it discharges. Gas will be removed from the top of the reactor and conveyed to the boiler system.

Each reactor contains sample ports, temperature sensors, a backwash drain line to drain contents from the media layer thereby removing any excess solids, a recirculation system and a sludge drawoff system. Reinforced concrete construction was selected for the reactors which will be covered by proprietary fixed steel covers. The tanks are fitted with access bulkheads below the media level and the covers contain gas tight manholes and sampling ports as well as gas safety equipment.

Recirculation System. Reactor contents will be recirculated through a drawoff piping network to provide mixing and to maintain the temperature of the

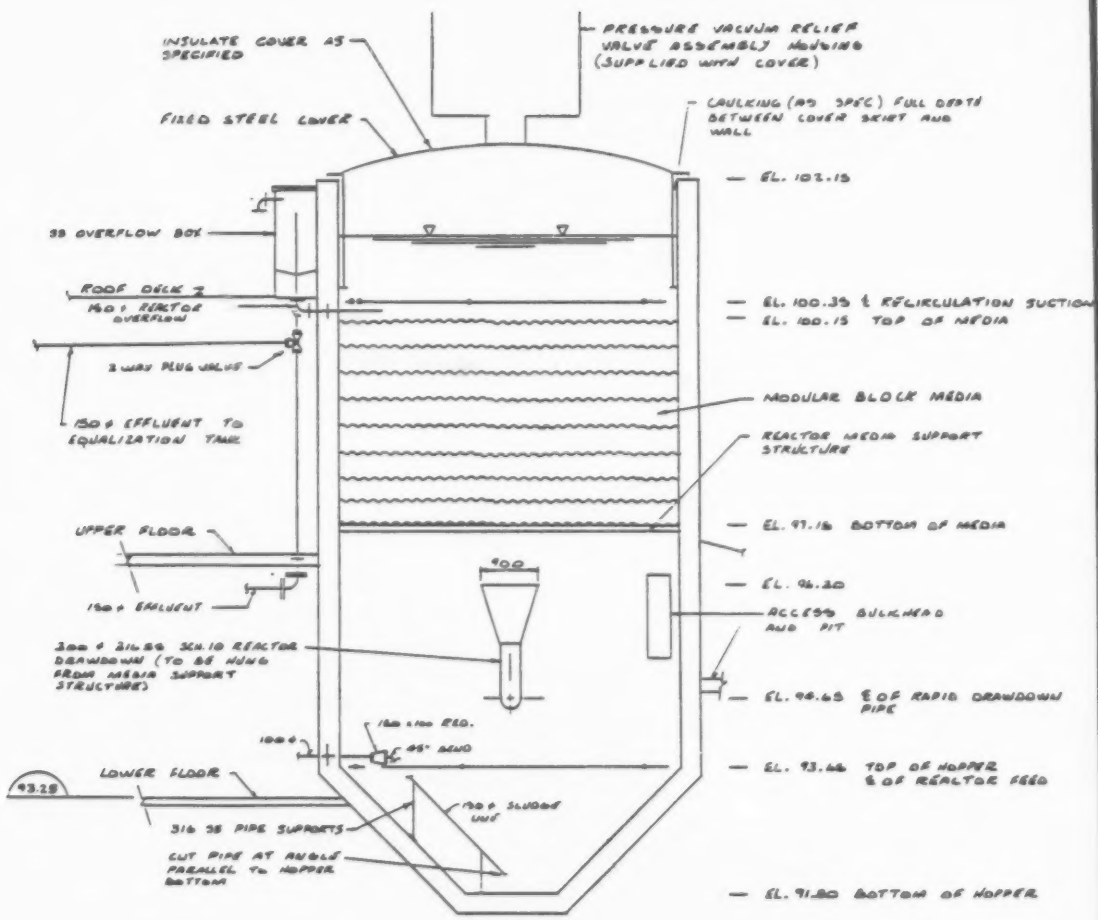

FIGURE NO. 3

ANAEROBIC REACTOR

DETAILS

reactors at 35°C. The recirculation ratio of reactors contents to influent will be established initially at a rate of 10:1. The recirculated contents will be directed along with the influent through spiral type heat exchangers. Duplicate heat exchangers have been provided so that each reactor system may be operated independently (and at different rates) and one system serve as back-up to the other. Heat exchangers are sized at capacities of 580,000 Kjoules/hr each, whereas recirculation pumps have a rated capacity of 26.1 m^3/hr.

Gas Flow Stream. Gas production is expected to occur at a rate of 0.50 1/g of COD removed. During the pilot testing, the methane component of this gas was consistently 72% by volume. At the initial and ultimate COD loads of 1,815 kg/d and 2,400 kg/d respectively, and projected COD removal efficiencies of 95%, methane generation is estimated at 620 m^3/d under initial conditions and 820 m^3/d under future conditions. This gas quantity converts to heating values of 938,000 Kjoules/hr under present conditions and 1.27 million Kjoules/hr under ultimate conditions. The energy derived from the gas will be utilized as a priority to maintain the reactor contents at 35°C with excess gas directed to space heating requirements or flaring.

The gas scheme is to be installed in accordance with the Canadian Gas Association requirements and will contain the necessary pressure vacuum relief valves, pressure gauging, flame traps, sediment traps, meters and other safety provisions.

Sludge Handling

The combined sludge (from settling tank and anaerobic reactors) will be transferred to a covered thickener of 5.5 m diameter and 3 m sidewall depth. The thickener will be equipped with a rotating scraper type mechanism complete with vertical pickets to improve thickening characteristics prior to dewatering. Supernatant will overflow a perimeter V-notch weir in the thickener to a sump from which it will be conveyed by submersible pumps to the equalization tank at the head of the treatment facilities. Thickened sludge will be transferred to the dewatering equipment automatically in response to a level signal in the sludge vat of the vacuum filter.

A skid mounted fully automated pre-coat vacuum filter system will provide sludge dewatering. This system consists of a pre-coat tank and pump, vacuum pump, filtrate pump and 6.5 m^2 vacuum filter. Sludge will be dewatered at a rate of 2 m^3/hr. The open tankage forming part of the vacuum filter will be covered and vented through scrubbers to the atmosphere. A sludge cake of minimum 20% solids will be produced and dropped directly into a dumpster located in the sludge dewatering room. This dumpster will be regularly emptied in the landfill. Filtrate from the operation will be directed to the reactor effluent system and the aerated lagoons.

Lagoon Modifications

The aerated lagoons will be used to polish the effluent from the anaerobic reactors. It was demonstrated in the laboratory studies that aerated lagoon treatment decreased residual COD, BOD and ammonia, while precipitating dissolved and suspended solids. To restore the existing lagoons to full service, the following modifications will be performed:

1. A new underdrain system is to be installed below lagoon # 1 to relieve hydrostatic pressure.
2. A new liner consisting of glacial till (site soil) will be placed over the new underdrain system of lagoon # 1.

3. The aeration system will be completely replaced using new coarse bubble air diffusers and associated piping with air supplied by the existing 40 HP blowers.
4. New and similar aeration equipment (to lagoon # 1) will be installed in lagoon # 2 following minor repairs to the existing liner.

The lagoons will receive effluent from the anaerobic reactors and the dewatering process. As well, the building underdrain system and the domestic and utility wastewaters will be directed to the lagoons for treatment and discharge.

Facility Building

The building will be installed in two levels with a main floor and a basement underlying approximately 75% of the area of the main floor. The layout of the main floor is illustrated in Figure No. 4 and shows the lab/office/control room located in such a manner as to provide visual contact of lagoons and access road. The reactors will be located at the north end of the building. Separate rooms are provided for various facility components as necessary to differentiate major functions. In addition, components that are associated in their activities are located in proximity to each other. It may be observed that the gas room (and reactor sampling room below) is separated from the remainder of the facilities with independent exterior access in accordance with the required codes.

The building will consist of a combination steel frame and concrete structure with exterior pre-cast ribbed block siding. All walls are to be insulated to R20 and the roof to R28. Partition walls will consist of concrete block and flooring will be trowelled concrete other than the washroom and office which will be tiled. The laboratory and control functions have been installed in the same room as the office to minimize space requirements.

The basement of the building will contain all of the sludge pumps as well as the reactor feed station and the pre-treatment tank blowdown system. Potable and utility water storage tanks and pumping systems are also located in the basement.

Heating of the reactors and building space will be provided by burning the reactor gas in a fire tube hot water boiler. Propane will serve as the stand-by fuel. Space heating is provided by floor mounted hot water radiation heaters in the office, lab and washroom areas, and ceiling mounted unit heaters in all other spaces. Thermostats will maintain desired temperature by throttling hot water flow through radiators and unit heaters. Occupied spaces such as the office, lab and washroom will be heated to 22°C, whereas all other spaces will be maintained at 12 to 13°C.

SUMMARY

The leachate treatment facilities at the Highway 101 Landfill are presently under construction with start-up expected in December of 1986. Contracts amounting to $0.38 million have been awarded for major items of equipment and a general construction contract for $2.8 million has been signed for installation of the works. Start-up of the treatment facilities will cap 3 years of research and development work conducted on behalf of the Metropolitan Authority of Halifax/Dartmouth and the County of Halifax and demonstrates a firm commitment by the Authority to environmental protection. Ongoing monitoring of both process performance and effluent quality exiting the lagoons is planned for a minimum of an 18 month period following start-up.

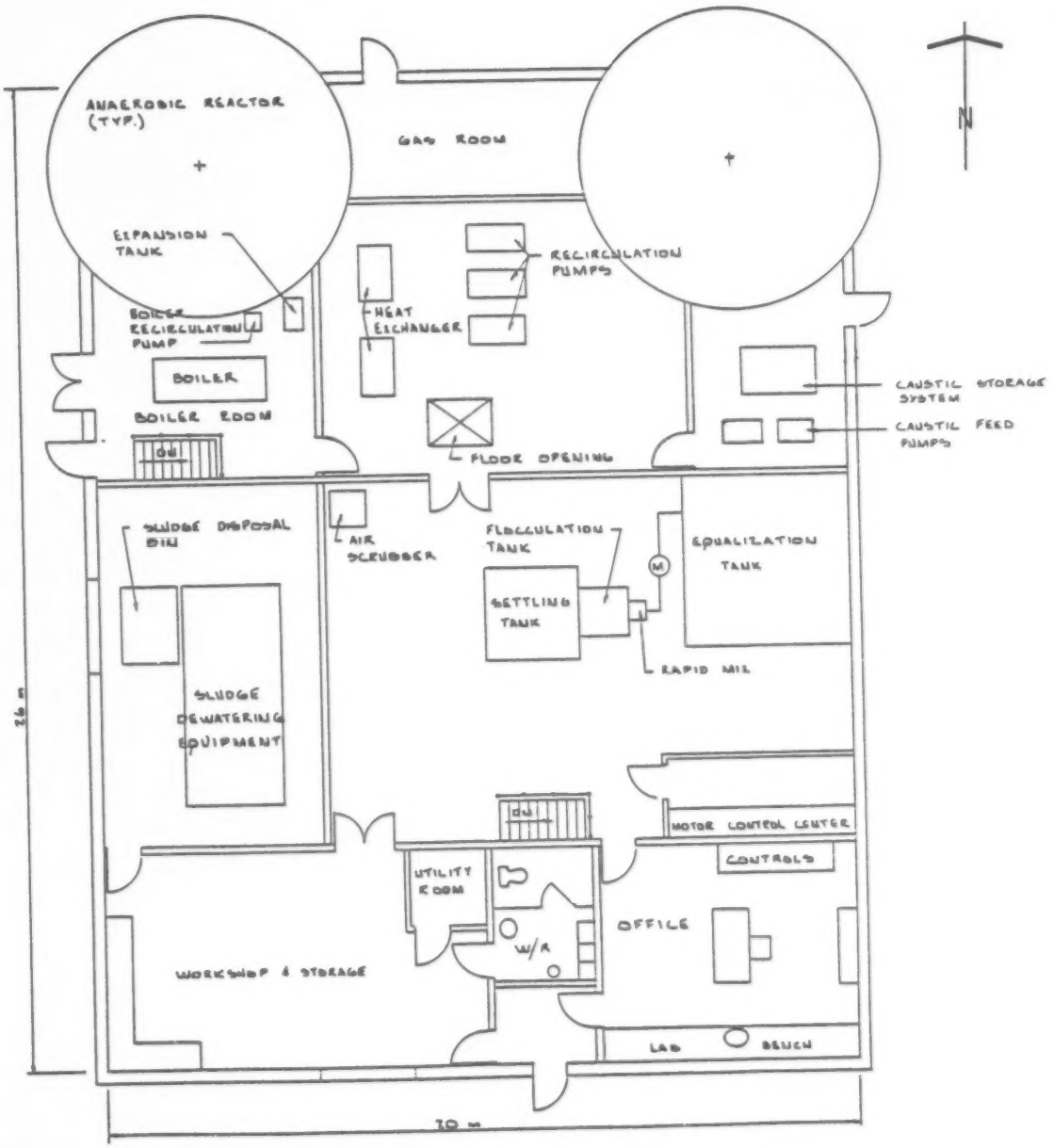

FIGURE NO. 4

MAIN FLOOR PLAN

THE SYDNEY TAR PONDS REMEDIATION PROGRAM

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